Washington State Department of Transportation

WSDOT Statewide Communications Plan
Final Report

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GROUP

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1. EXECUTIVE SUMMARY

1.1 INTRODUCTION

The Washington State Department of Transportation (WSDOT) has identified the need for a Statewide Communications Plan that provides strategic direction for the management and expansion of WSDOT's communication infrastructure. Beyond the need for WSDOT offices across the state to conduct their daily business, WSDOT is known as a leader in the deployment of Intelligent Transportation Systems (ITS), and accordingly has installed as-needed communications infrastructure to support the transfer of data and video images from ITS field devices and transportation management systems. This information is used by WSDOT to monitor and manage the statewide highway system and provide the traveling public with real time travel information.

WSDOT's Light Lanes project was a recent initiative intended to deploy a 700+ mile fiber optic communications network statewide (primarily in WSDOT freeway and highway right-of-way) in order to provide a communications backbone for ITS field devices and to facilitate inter-regional information sharing. Unfortunately, with the economic collapse of the telecommunications industry, there was no longer any interest from third parties to participate in building the Light Lanes network, leaving WSDOT to look for other alternatives and setting the stage for this study.

The Technology Solutions for Transportation Operations[1], the Washington Statewide ITS Architecture, and the stakeholder interviews/literature review conducted for this Communications Plan, have all identified the need for greater center-to-center communications between WSDOT regions, the Washington State Patrol, and local municipalities; for incident management, traffic control, and improved day-to-day operations. Other recognized needs, including the deployment of additional ITS field devices and "smart" vehicle initiatives, will also require expanded center-to-field and center-to-vehicle communications. The effort has clearly identified the increasing need for a high speed and reliable communications network to support the daily operations and business functions of the Department. Thus, the purpose of the Statewide Communications Plan is to:

"Set Strategic Direction for the Implementation of a Statewide Communications Network to Serve the State Transportation Systems Management, Video, and Integrated Data Needs"

1.2 FINDINGS

An extensive review of the current, planned, and required communications infrastructure was completed as part of this effort. The findings of this review provide the basis for the development of the recommendations detailed in the Statewide Communications Plan. The findings are summarized below:

- **Inter-regional Communications**: Office-to-Office data and video information flows and communications requirements between one of WSDOT's six regions and the State Headquarters (HQ) in Olympia or between regional Transportation Management Centers

[1] Document currently under development

(TMCs) constitute inter-regional communications. These information flows include enterprise and administrative functions, as well as those required to support ITS initiatives. The existing network consists primarily of communication lines leased from telecommunications providers, which are configured in a star topology radiating from Olympia to the regional headquarters and offices to serve these enterprise and administrative needs. Communications traffic between regions (voice and data) is routed from one region through Olympia HQ and back out to the other region.

These higher capacity leased line links are used for phone service and to create the WSDOT Wide Area Network (WAN). The WAN allows all connected WSDOT offices access to email, the Internet, and the WSDOT Intranet, over which many broadband applications are accessed. This network also allows transmission of highway condition camera images and data from each region for posting on WSDOT's statewide traveler information website housed at WSDOT Headquarters.

Of the inter-regional connections, currently only the link between WSDOT Headquarters and the South Central Region is at a utilization level that would result in reduced response times and performance. However, several of the other primary links are nearing this threshold. More importantly, WSDOT is concerned about network reliability and is currently very reliant on private communications providers for these leased line connections. The star topology by nature offers limited redundancy between sites, further adding to concern about network reliability.

This well managed and monitored network will require expansion in the future to accommodate additional demands. Anticipated growth in employee network use and the centralization of more Departmental applications will increase traffic on the network. These applications include expansion and centralization of performance monitoring, State Route View (SRView – which provides digital images of state routes), aerial photograph access, computer aided design applications, geographic information systems, and digitizing of construction documents.

The growth in ITS bandwidth requirements will expand as the number of cameras (both "snap shot" image and the move to full motion video) and other devices and sensors are deployed in the field and this information is transmitted to Olympia for posting on the Internet. Additionally, neighboring WSDOT regions will become increasingly interested in sharing access (and possibly control) of each other's cameras and devices, particularly as more are deployed near regional boundaries. A potential ITS development that could have serious bandwidth implications is the proposed Statewide Traffic Operations Center/Emergency Operations Center (STOC/EOC) in Olympia which would have real-time access to cameras, sensors, variable messages signs (VMS), highway advisory radio (HAR) and WSDOT Regional Traffic Management Centers (TMCs) across the state.

- **Intra-regional Communications**: Intra-regional communications include office-to-office data and video information flows and communications requirements within a given WSDOT region. These information flows include enterprise and administrative functions, as well as those required to support ITS initiatives. Lower capacity leased lines are used to link smaller WSDOT offices within the region to the WSDOT WAN. Connections may utilize dedicated

point-to-point leased lines between a site and the regional HQ, or they may utilize a shared (Frame Relay) "cluster" of leased lines, where several sites share a connection back to the regional HQ. These leased lines are routed back to the Regional Headquarters and then on to Olympia. Several leased line links between Regional Headquarters and offices within the region are being utilized at rates that can result in reduced response time (network slowdown) and performance issues. Enterprise needs are expected to grow over time.

Fiber networks have been installed in some of the WSDOT regions to connect regional WSDOT TMCs with local field equipment (cameras, sensors, etc) and, in more and more cases, with local jurisdiction TMCs. These direct links to cameras and sensors provide superior transmission performance. The demand on these primarily ITS fiber networks will grow as more devices and local TMCs are added. A very limited amount of fiber has been installed by WSDOT for enterprise needs. There are some opportunities for using WSDOT owned fiber for enterprise purposes and thus reducing dependency on leased communications lines.

- **Phone/PBX Network:** WSDOT has configured and maintained a telephone network that allows interoffice dialing (between WDOT offices) without the use of the public switched telephone network (PSTN). The primary feature of this network is the ability to use 4 digit dialing between any connected WSDOT offices in the state, eliminating long distance charges on such telephone calls. Telephone service in these WSDOT offices is provided using a PBX (Private Branch Exchange). Other smaller offices do not have 4-digit dialing and are connected directly to the PSTN. The interconnections between PBXs can be carried on leased lines or over channels on the microwave system maintained by the Washington State Patrol (WSP). The demand for voice service is primarily depended upon the size of WSDOT staff in each facility.

- **Center-to-Field Voice Communications**: WSDOT's operations rely heavily on their 800 MHz radio network to communicate with staff in the field, whether they are maintenance personnel, construction administration, incident response or other individuals performing field design work. The 800 MHz radio network is operating near capacity. In several locations, interference from same-band digital systems is impacting performance. Plans are underway to migrate to a 700 MHz system and move toward a radio system that is interoperable with WSP.

  Radio users can speak to each other because radio transmission towers are connected over a state-owned backbone microwave network that is primarily maintained by WSP. Besides WSDOT and WSP radio traffic, this microwave network is also used for data and phone communications for WSP operations. Opportunities exist to upgrade the capacity of this microwave system to provide redundant and reliable communications for both WSP and WSDOT operations, including data and PBX traffic, and thus reduce the use of leased lines while increasing network reliability and redundancy.

- **Center-to-Field Data And Video Communications**: This communication demand centers on video and data requirements for center-to-vehicle and center-to-field devices, which are primarily ITS initiatives. For Center-to-vehicle communications, both incident response team (IRT) program and the Smart Snowplow pilot project use vehicles that are equipped with laptop computers, sensors, vehicle location devices, and wireless communication equipment to

keep their dispatchers informed of current conditions and locations. As both programs expand and if video images from the field are added, the communications demand will increase. ATandT Wireless is phasing out the current CDPD service that provides communications to many of the IRT vehicles. The current 800 MHz radio system will not be able to accommodate the increase in traffic.

Communications from regional WSDOT TMCs to ITS field equipment have been established based on regional design decisions. Almost every type of communications medium has been deployed. These "last mile" connections can be the most difficult to design and deploy. This incremental and regional approach has provided WSDOT with valuable experience in multiple technologies. However, the lack of standardization can increase maintenance and operational costs. WSDOT has extensive plans to deploy more ITS field equipment throughout the state. The demand for these types of communications will grow accordingly.

- **Policy Issues**: WSDOT and WSP, under the Joint Operations Policy Statement (JOPS), have agreed to "create a coordinated and integrated wireless transportation communications [network]." While both parties have accepted this language, the key will be to translate this policy into specific actions, committees and deployable projects.

  Other policy modifications could result in better standardization of design practices, consistent review of design and/or construction to ensure "best practices" are employed, and better coordination to support ongoing maintenance requirements.

- **Telecommunications Market Review**: Specifically, the goal of this activity was to identify opportunities to obtain fiber optic plant from telecommunications providers who might be willing to sell (or lease long term). The rationale was that perhaps the collapse of the telecommunications market had opened up an opportunity to purchase existing fiber and/or conduit at low cost. This fiber could then potentially be used for either center-to-center or center-to-field applications, depending on route, location, etc. Over a dozen providers have been identified as possibly owning infrastructure on key corridors of interest to WSDOT. Several are providing pricing for WSDOT info for various key circuits. 360networks has indicated an interest in possible long-term lease of dark fiber on I-5 corridor. NoaNet appears to be a "best fit" for locations, availability and pricing at this point.

1.3 RECOMMENDATIONS

This wide-ranging analysis of the existing communications networks, methods and future requirements reveals some excellent opportunities for cooperation and synergy with the promise of increased communication capacity, improved redundancy and lower operational costs. The needs and technical complexities are significant. Continuation of WSDOT's cooperative and active management will be required for success. In general terms, the WSDOT statewide communications network must serve all communication needs for daily and emergency operations with adequate capacity, redundant paths, reliable service, while being cost effective. The network should remain a hybrid network (i.e., part state owned, part leased), but one that maximizes utilization of state-owned infrastructure, including the microwave, fiber, and radio networks. WSDOT should continue to use leased line communications where cost effective or where required for redundancy. Key specific recommendations are as follows:

1. **Establish a joint WSP/WSDOT Communications Task Force:** The charge of this task force is to make strategic decisions on communications infrastructure. Activities would include a review of the existing communications infrastructure for redundancy opportunities, development of a joint plan for an ultimate network, assess build/buy/lease opportunities to obtain best arrangement for both agencies, develop a wireless subcommittee to review the design of ALL wireless construction projects, and development of necessary interagency agreements.
2. **Upgrade Microwave Backbone:** WSDOT should work together with WSP to increase the capacity of selected segments of the microwave network for data and voice service. WSDOT priorities should consider "high utilization segments", center-to-center connections for ITS, and high cost leased line segments. Specific opportunities are identified in the report.
3. **Upgrade Over-Utilized Communication Links:** Specific links that provide communications to WSDOT offices are over-utilized, resulting in a reduced level of service. Benefit/cost analysis should be performed comparing adding additional leased line capacity vs. upgrading and utilizing existing infrastructure, particularly the fiber and microwave networks. This analysis needs to compare life cycle, in addition to, initial capital construction costs. Specific opportunities are identified in the report.
4. **Review Use of WSDOT-Owned Fiber:** Analyze the WSDOT-owned fiber optic network for its capability to support WSDOT enterprise data and communication needs to for replacing leased lines. There is the potential to use existing dark fiber, reallocated fibers and electronics upgrades.
5. **Explore the 360networks Fiber Run along Interstate 5:** 360networks owns fiber optics cable near I-5 from Vancouver to Everett. 360networks has indicated an interest in long-term lease options for dark fiber and possibility of installing additional manholes or splice points if required. This could reduce the cost of leased lines along this corridor and may be able to access field devices (particularly CCTV cameras). However, it should be noted that the fiber run from Chehalis to Spanaway takes an alternate route, veering well away from I-5.
6. **Bandwidth Management for Video Traffic:** There are techniques (and equipment) that can dynamically manage the bandwidth utilized for the transmission of digital video images, which "expand or contract" the bandwidth to meet the current need, priorities and available bandwidth. These techniques could be used to reduce the demand on the communications network for the transmission of the video images to WSDOT Headquarters for placement on the WSDOT traveler information website.
7. **Use WSDOT Radio Network for Communication to Field Devices:** Look for opportunities to use the radio network to communicate with field devices that have low data requirements, instead of using leased lines with monthly fees.
8. **Upgrade the WSDOT Radio Network:** We support the Wireless Task Force recommendation to upgrade the radio network to 700 MHz. This change will provide additional capacity for voice, data to vehicle, and data to field devices, and alleviate the current interference problems. The upgrade must ensure interoperability with WSP.
9. **Formalize Policy of Installing Fiber Optic Cable as Part of New Projects:** Fiber optic cable has generally been installed as part of the Surveillance, Control and Driver Information

(SCandDI) element of freeway or HOV lane widening projects in the state. This informal practice should be formalized in WSDOT design directives and considered for major reconstruction projects. Key routes should be identified and prioritized. This will reduce the dependence on leased lines and provide an alternate route for microwave traffic. This report indicates some possible high priority corridors for expanding the fiber optic networks, based primarily on density of WSDOT offices and/or field devices.

10. **Conduct I-5 Corridor Communication Analysis:** The I-5 Corridor has the potential for the biggest cost savings through detailed analysis of communications options. This corridor includes four TMCs (five including the proposed Statewide TOC), three regional headquarters, the state headquarters and the highest density of ITS devices. There are also multiple communications options, including 360networks fiber, leased line opportunities and the microwave network, that should all be included in this analysis. It is recommended that this corridor be broken down into individual segments for further lifecycle, cost/benefit analysis of communications options.
11. **Implement Asset Management System:** The current decentralized approach of documenting WSDOT communications assets does not always provide the needed information to make informed and coordinated communication infrastructure expansion decisions, while at the same time increasing effort (and cost) of maintaining the network. An asset management system should be implemented to document information concerning fiber, communications equipment, ITS devices, etc.
12. **Evaluate Satellite for Remote Sites:** The Eastern Region has begun utilizing satellite communications for data connections to remote sites (maintenance sheds) where leased line options do not exist. It is recommended that WSDOT perform further analysis of the cost and benefits of this application, and determine if it is applicable to other remote sites, particularly in North Central, South Central and possibly Olympic Peninsula.
13. **Policy for Redundancy:** WSDOT should develop a strategy and implement specific policy on redundancy requirements for communications. Several of the larger sites, including regional headquarters, TMCs, Project Engineering offices and Maintenance Area offices have been identified as requiring additional redundancy during emergencies or even simply to avoid loss of connectivity during daily activity. However, no specific policy exists on which business functions require what specific level of redundancy.
14. **Spare Capacity Guidelines:** In order to support network growth and flexibility, it is recommended that WSDOT develop a strategy on spare capacity, including a specific set of guidelines. Different levels of spare capacity are recommended for different applications, for example, it is relatively easy to add additional capacity to a leased line connection and generally does not require additional capital expense, whereas, it is much more difficult and costly to add capacity to owned infrastructure such as fiber or microwave. There are also different requirements for spare capacity in different network elements, including fiber, transmission equipment, equipment chassis, equipment racks and even floor space in communications facilities.
15. **Standardize Communications Protocols:** In order to support operations and maintenance, as well as interoperability of the network, it is recommended that WSDOT standardize on a set of specific communications protocols for various applications. Examples may include: SONET, T-1/T-3, TCP/IP, RS-232 and P25 (wireless.) WSDOT should formalize standards

on NTCIP for ITS applications. WSDOT may consider standardizing on Gigabit Ethernet backbones for TCP/IP networks with specific carriers or when dark fiber is available.

16. **Coordination with Maintenance:** It is recommended that WSDOT implement a policy of closer coordination with maintenance personnel during the design and implementation of new systems. Different departments take over maintenance responsibilities of different systems, depending on the application and in some cases, the region. It is important to identify who will be maintaining the equipment on an ongoing basis, for any new implementation, and ensure that they are involved in some phase of design review. Through this process, it can be verified that they have (or can obtain) both the technical training and equipment required for ongoing maintenance. It is also important to ensure that they have assigned proper budget and staffing requirements (FTEs) for ongoing maintenance.

2. PROJECT METHODOLOGY

This section introduces the project vision and approach, as well as describing the organization of this report. A guide to communications terminology is also included for general information and reference.

2.1 PROJECT VISION STATEMENT

To facilitate the development of the Communications Plan and to encompass the communication needs of the stakeholders; the project team proposed and accepted the following vision statement:

"Set Strategic Direction for the Implementation of a Statewide Communications Network to Serve the State Transportation Systems Management, Video, and Integrated Data Needs"

The steps required to meet this vision are discussed in the following subsection.

2.2 TASKS

Initially, this project was intended to provide communications requirements primarily for WSDOT's ITS operations. However, once the project began, it became apparent that enterprise-wide guidelines were needed, and that there was an opportunity to provide greater benefit to WSDOT by considering a wider range of the organization's requirements. The original project scope and task list was then revised and approved by the project team and stakeholders.

A work flow diagram is shown in Figure 1. The following tasks were undertaken in the preparation of the Communications Plan:

Review Work to Date: To gain a complete overview of WSDOT's communication efforts to date, the project team reviewed all past work on the Light Lanes project and other relevant documents provided by WSDOT.

Stakeholder Input: Project stakeholders, in this case WSDOT regional traffic engineers, were interviewed in order to determine their perceived communications needs for current and future operations.

Determine WSDOT Enterprise Requirements: The project team conducted two working sessions with WSDOT staff, as well as over a dozen interviews with regional engineering, maintenance, telecommunications and IS/IT staff. The results of these meetings are discussed in Section 3 and were used to develop the requirements presented in Chapter 4.

Determine Center-to-Center Requirements: This task focused on statewide transportation data exchanges between WSDOT facilities in each region.

Determine Center-to-Field Requirements: This task focused on control and data exchanges between WSDOT Transportation Management Centers (TMCs) and associated field devices.

Inventory Existing Communications Equipment: WSDOT compiled an inventory of all existing and programmed communications infrastructure, including all fiber optic, microwave, twisted pair, hubs, etc. From this information, a geodatabase and GIS interface was developed to allow development of customized reports and maps.

Network Planning Study: The network planning study considered the communication needs of the WSDOT network and developed a plan to provide the required bandwidth between major communication hubs, including WSDOT offices and control centers. The network plan identifies communication links that are required by segment and by communication technology (microwave, leased line, owned fiber or other).

Assess Technologies: Using the results of the previous tasks, the project team was able to assess the ability and appropriateness of various technologies to meet WSDOT's requirements.

WSP Network Sharing Analysis: The purpose of this task was to work with Washington State Patrol (WSP) to gather information on the WSP statewide microwave backbone and radio network, as well as to identify and discuss institutional issues surrounding the opportunities for WSDOT to utilize this network. An important part of this task was to also gain a better understanding of WSP's requirements and to ensure that they are also supported by any final recommendations.

Telecom Market Survey: Telecommunications service providers, wholesale providers and others who may own and/or broker sales of telecommunications infrastructure in the State of Washington were surveyed, with the intent of looking for opportunities to buy (and/or long term lease) available fiber and/or bandwidth.

Evaluate Alternatives: Alternative communications concepts were developed and presented to stakeholders for evaluation, comment and review.

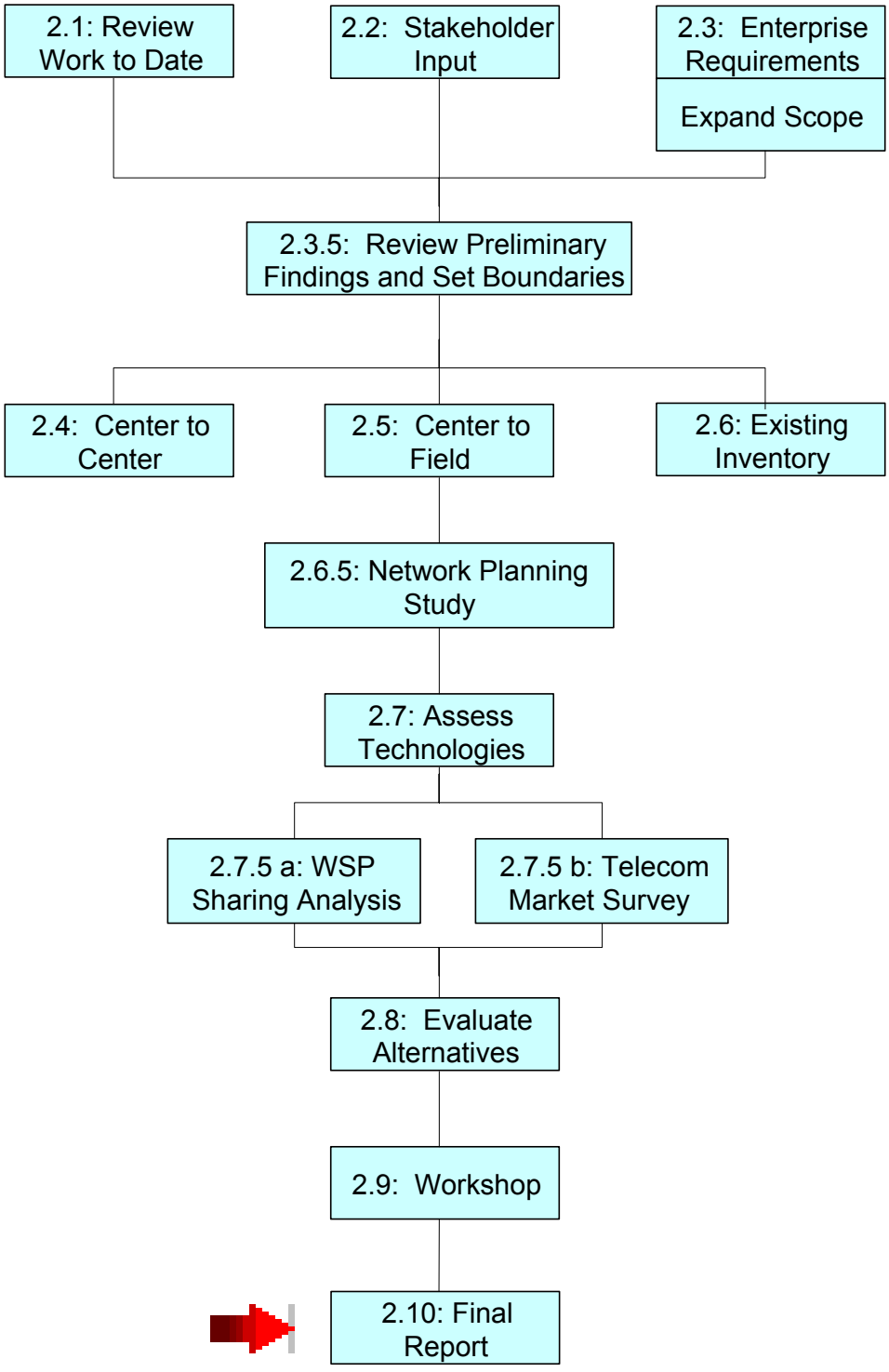


Figure 1: Communications Plan Workflow

2.3 FORMAT OF FINAL REPORT

2.3.1 Report Chapters

The Final Report is broken down into the following four Chapters:

- **Chapter 3: Findings**—this section introduces issues identified during interviews, report reviews, meetings, presentations and other data collection efforts.

- **Chapter 4: Requirements**—this section identifies a list of requirements of the WSDOT Communications network, identified as a combination of industry "best practices" and agency needs as identified in Findings.

- **Chapter 5: Analysis**—this section includes a compilation and review of data and information, with particular focus on agency requirements and existing infrastructure. This analysis involved development of specialized GIS maps to analyze specific issues and opportunities.

- **Chapter 6: Recommendations**—this section includes a high-level "Strategic Direction Statement" for the WSDOT Communications Plan and a series of specific recommendations.

2.3.2 Report Categories

Each of the four chapters are further broken down into the following categories (or subsections):

- **Inter-regional Communications**: Office-to-Office Data and Video communications requirements between WSDOT Regions or between a Region and State HQ—including IT, Enterprise and ITS

- **Intra-regional Communications**: Office-to-Office Data and Video communications requirements within a given WSDOT Region—including IT, Enterprise and ITS

- **Phone/PBX Network**: The WSDOT voice network, interconnecting the various offices on a network operated by WSDOT

- **Center-to-Field Voice Communications**: To vehicle and mobile handsets—including backbone and distribution communications

- **Center-to-Field Data and Video Communications**: To vehicle and/or field devices—including backbone and distribution communications

- **Policy Issues**: Policy issues that impact either communications needs or specific recommendations

Some of the chapters contain additional subsections, as required, but each includes these six categories at a minimum.

2.4 COMMUNICATIONS TERMINOLOGY

This subsection provides some background information on common communications technology terms.

2.4.1 Traditional Telephone Lines

Traditional telephone lines use a pair of copper wires (a twisted pair) to provide an analog communication channel. While analog circuits are still widely used in telephone systems, voice channels are typically converted to digital signals at some point in the network, and it is now rare that two telephone callers would talk over an interconnected pair of wires for the entire route between them.

The first approaches to digitizing voice signals converted the analog voice channel to a data stream of 56 or 64 kbps. This level of digitization is termed a DS-0, for digital signal level 0. In later years it has become possible to compress voice into smaller channels than 56kbps, but DS-0 is still used widely as a basic building block for uncompressed channels.

2.4.2 Data Circuits

The 56kbps channel has been retained as the basic building block for a wide variety of data services that are leased by telecommunication providers, as shown in the following table.

Service	Data Rate	Common Protocols	Capacity	Equivalent Voice Channels
DS-0	64kbps	Voice RS-232 V-35; DS-0	One uncompressed Voice signal	1
T-1	1.544Mbps	DS-1 V-35	24 DS-0 Channels	24
T-3	45 Mbps	DS-3	28 T-1 signals	672
SONET OC-3	155 Mbps	SONET	3 T-3 signals	2,016
SONET OC-12	622 Mbps	SONET	12 T-3 signals	8,064
SONET OC-48	2.49 Gbps	SONET	48 T-3 signals	32,256
Frame Relay	Varies	V-35 RS232	Shared Capacity	Varies
Ethernet	10Mbps 100Mbps 1000Mbps	10Base-X 100Base-X 1000Base-X	2.5 Mbps 25Mbps 250Mbps (approximate capacity on shared channel)	44 440 4,400
Video (Uncompressed)	45Mbps	Proprietary	One NTSC Video	2,016
Video (Compressed)	10Mbps	MPEG2	One NTSC Video (compressed)	44

These circuits or leased lines are provided over the telephone network to the customer's premises. At the end of the leased line, a DSU (Data Service Unit) converts the signals carried by the telecommunication network into a standard data protocol as shown in the table above. In a point-to-point circuit, two locations would be connected with the leased line, and DSUs at each end of the circuit would allow the two locations to communicate using the selected protocol and data rate.

2.4.3 Frame Relay

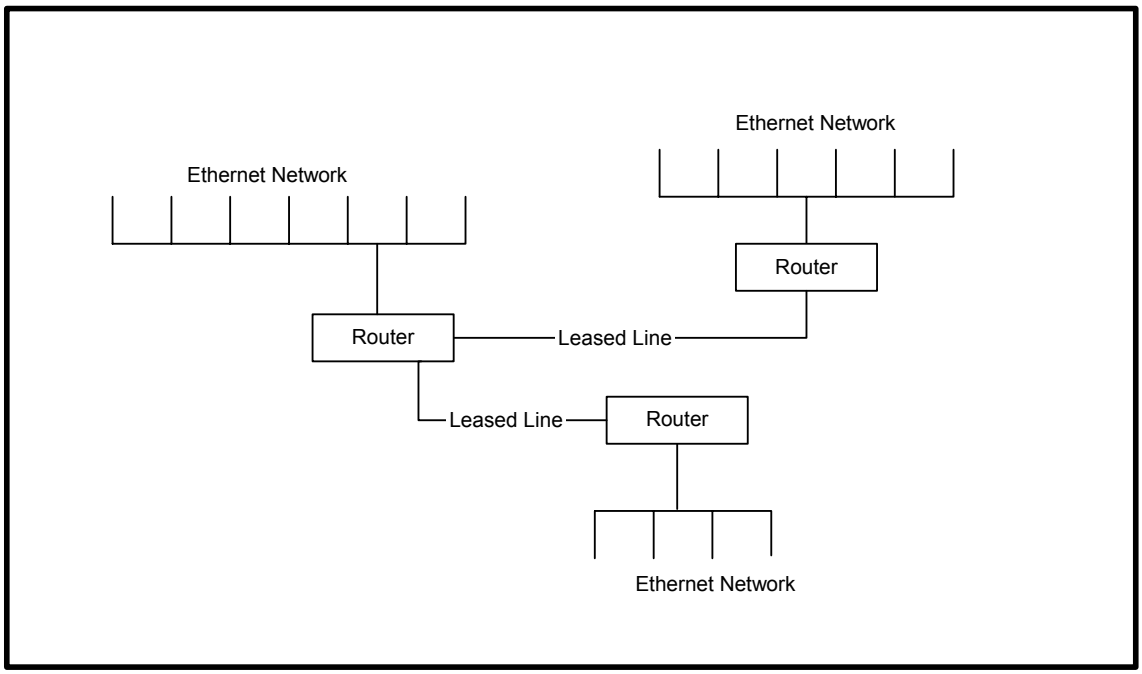
Before the advent of modern computer networks, it was common that one central computer would need to communicate with a number of remote locations. A point-to-multipoint circuit was developed to meet this need, which divided the stream of data up into small chunks (frames) and directed (relayed) each frame to the correct destination. These frame relay circuits are still available from telecommunication suppliers, and provide an economic means of combining the data traffic from a number of remote locations. For the purposes of this document, these groups have been termed “frame relay clusters”.

2.4.4 TCIP/IP Networks

The vast majority of computer networks use Ethernet communication, which allows all connected computers to talk on a common channel. Similar to frame relay networks, the information to be sent is divided up into packets and sent out over a network to the intended recipient. The traffic is switched and routed to the recipient based on an addressing and routing protocol called TCP/IP (Transmission Control Protocol/Internet Protocol).

Ethernet requires large bandwidth connections operating at 10, 100 or 1000Mbps that can only be carried for short distances on twisted pair wiring. Although long distance transmission is possible using fiber optic cables, the telecommunication providers typically do not lease "dark" fiber without the electronics that light the fiber and provide the communication link.

In order to extend the span of an Ethernet network, routers are used at strategic locations. In addition to directing the transmission of the Ethernet traffic as the name suggests, routers can also translate Ethernet traffic into any of the communication protocols discussed above. With a leased line between two buildings, routers at each end can be equipped with appropriate WAN (Wide Area Network) interface cards as shown below.



2.4.5 WSDOT Networks

WSDOT has implemented a WAN that provides statewide interconnection of the TCP/IP network. The main state facilities are equipped with routers and interconnected with leased lines. At this time, WSDOT uses the following types of leased lines to interconnect the routers:

- 56kbps Point-to-Point
- Frame Relay (Typically with an aggregate bandwidth of 1.0 Mbps)
- T1 circuits
- T3 circuits

2.4.6 Network Monitoring and Utilization

All of the routers used by WSDOT are monitored and managed remotely over the network. This allows the IT group in Olympia to monitor the health of the network in real time, including the presence of the communication link and the utilization (traffic load) on each link. In addition to the real-time monitoring, the daily utilization of each leased line is well documented by the IT group, for historical trends and to identify links that require additional capacity.

Due to the nature of computer traffic, experience has shown that users will start to notice network delays when the utilization of WAN leased circuits starts to exceed 30%. When this utilization exceeds an average of 40% the problem will reach a significant level and the IT group will start to receive calls from dissatisfied users. The nature of WSDOT's network usage (like most entities) is that the traffic is continually increasing over time, so a level of 20% utilization has been adopted as an indicator that some action is required to provide additional capacity on a section.

3. FINDINGS

This section of the report summarizes the key findings from the WSDOT Statewide Communications Plan development effort. These findings include information collected during several different tasks, as well as the results of numerous interviews, team meetings, report reviews and site visits. Many of the Network Architecture diagrams were obtained from the WSDOT Office of Information Technology (OIT) and are reprinted with permission.

Through the course of the interviews and meetings, it became apparent that there are a number of different ways in which information flows and the associated communications requirements for video, voice or data may be categorized. Five main categories of information flows and communications requirements have been defined for this report, as follows:

- **Inter-regional Communications**: Office-to-Office Data and Video information flows and communications requirements between WSDOT Regions or between a Region and State HQ. These information flows include Enterprise or Administrative functions, as well as those required to support ITS initiatives.

- **Intra-regional Communications**: Office-to-Office Data and Video information flows and communications requirements within a given WSDOT Region. These information flows include Enterprise or Administrative functions, as well as those required to support ITS initiatives. They may also include information flows with other agencies, such as local municipalities, city TMCs, Emergency Response agencies, etc.

- **Phone/PBX Network**: Basic voice phone service for WSDOT offices, whether used primarily for internal WSDOT 4-digit dialing or long distance dialing. This system supports a video conferencing system available at a small handful of offices.

- **Center-to-Field Voice Communications**: Includes person-to-person and dispatch-to-field communications, and includes both vehicle mounted radios and hand-held mobile radios. The network that supports these communications includes both a backbone microwave network and a distribution radio network, which are defined in more detail later in this section.

- **Center-to-Field Data and Video Communications**: Includes center-to-vehicle and center-to-field devices, along with video and data requirements, which primarily support ITS initiatives.

In addition to these five categories of information flows, a sixth category was added:

- **Policy Issues**: Includes issues that impact either communications needs or subsequent specific recommendations.

3.1 INTER-REGIONAL COMMUNICATIONS

The bulk of WSDOT's inter-regional communications and information flows tend to be between regional offices and WSDOT Headquarters, with minimal region-to-region communications. This seems to be the case for both administrative/enterprise communications and ITS communications, including voice, video and data.

The remainder of this subsection (and subsequent subsections) discusses the following elements:

- **Existing Infrastructure and Architecture**: Describes existing inter-regional owned or leased infrastructure, bandwidth size and network architecture.
- **Traffic**: Types of traffic on the network, including discussion on voice, video, data, and specific applications.
- **Utilization**: Levels of utilization of the existing network.
- **Planned Upgrades**: Discussion of any known upgrades to the above infrastructure that are already planned or underway. Occasionally, bandwidth connections differ when compared to those shown in the network diagrams from WSDOT OIT. These have been discussed under planned upgrades, although in some cases they may have already been upgraded.
- **Growth**: Qualitative discussion of potential growth of network utilization, based on current trends and other issues identified during the data gathering tasks.

3.1.1 Existing Infrastructure and Architecture

Figure 2 illustrates the Network Architecture of sites fed directly from the Olympia Headquarters (referred to in the diagram as Olympia Service Center or OSC). The majority of these connections are leased line connections—except for the fiber connections indicated in the figure— and the majority of the leased lines are either point-to-point T1 or Frame Relay T1 circuits (shared between multiple sites). In addition, there is a T-3 ATM Circuit between the Olympia HQ and Northwest Region HQ (indicated as Dayton HQ in Figure 2).

Six of the sites fed directly from Olympia Headquarters (Oly HQ) are the WSDOT Regional Headquarters buildings. The site indicated as "2911 Building" is one of the primary Washington State Ferries (WSF) facilities (the other primary WSF facilities are connected to 2911 via fiber). This segment indicates the connection between WSDOT Oly HQ and WSF. For the purposes of this report, these seven sites (identified in Figure 2), and their associated connections to Oly HQ, have been defined as the key inter-regional Communications Connections.

Figure 3 illustrates these seven key inter-regional connections geographically. This figure is an output from the Geographic Information System (GIS) database developed specifically for this project.

Each one of these connections is leased (at varying monthly rates) from one of several private telecommunications service providers. The service provider generally offers some sort of Level-of-Service guarantee, which usually covers bandwidth availability, maximum downtimes and repair procedures.

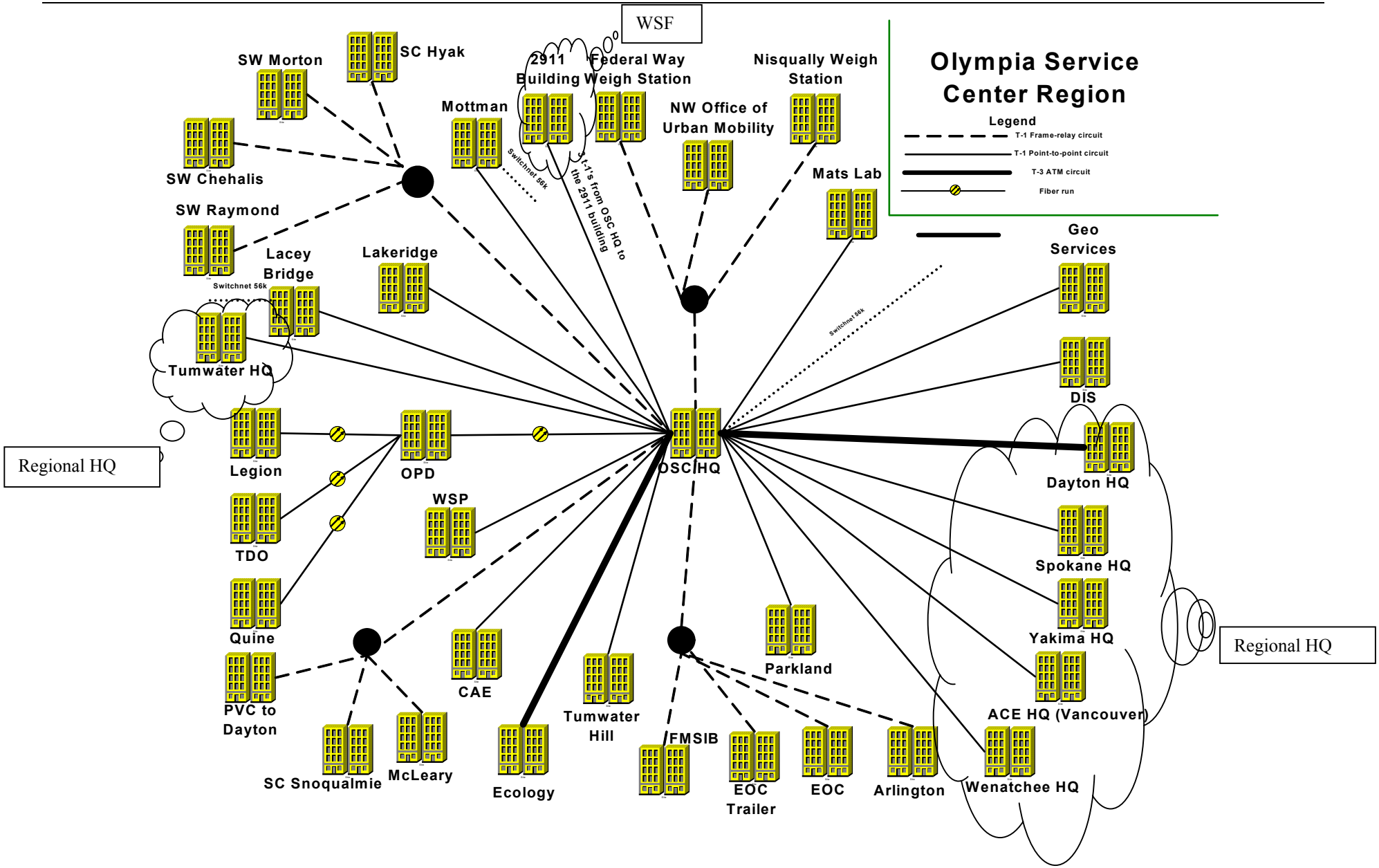


Figure 2: WSDOT Sites fed from Olympia Headquarters

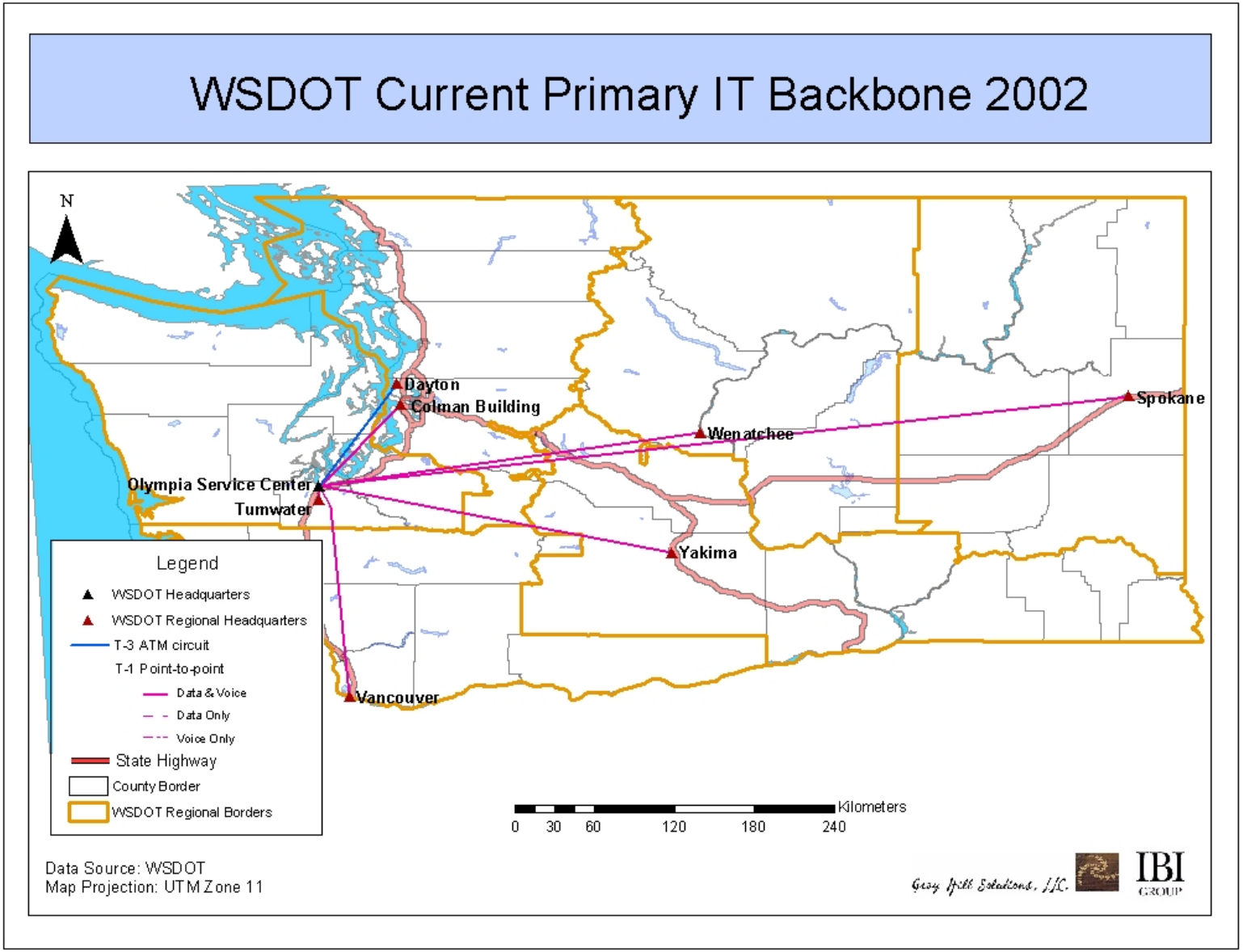


Figure 3: WSDOT Primary Inter-regional Leased Lines

3.1.2 Communications Traffic

3.1.2.1 Enterprise/IT

This network of inter-regional leased lines is used for voice, video and data communications. In regards to voice communications, the phone network utilizes these leased lines. This network is discussed in more detail under the Phone/PBX section below. These links are also used to create the WSDOT WAN, which allows the regional offices access to email and the Internet, as well as to the WSDOT Intranet. WSDOT Intranet applications include SRview, AutoCAD, and Microstation.

Due to the fact that WSDOT utilizes a star topology, these inter-regional connections are heavily utilized. Under the star topology, all of the regional data or video traffic that is to go through the Internet, either from the region to Olympia or between regions, utilizes these inter-regional connections. Figure 4 illustrates this point, by showing a generic region with field offices, a TMC and Regional Headquarters, and the star topology connecting these offices back to the Olympia Headquarters and then out to a different Regional Headquarters.

3.1.2.2 ITS

These same inter-regional leased line connections are used for ITS video and data traffic as well. Probably the most significant application (from the bandwidth perspective) is the posting of video images from the CCTV cameras located in each region to the Internet. Each of these video images are sent from the camera in the field, to the local TMC (whether in full motion, snap shot or reduced frame motion.) From the regional TMC, the images are sent as snapshot images[2] to the Internet using the regional HQ to Olympia HQ connections.

In addition to the video images, significant amounts of data are sent from the regional ITS devices through the regional TMCs and on to Olympia for data storage, as well as for a number of applications. Some of these applications include:

- **Traffic Flow Maps:** Using data from traffic detectors
- **Pass Conditions:** Using data from Road Weather Information Systems (RWIS)
- **Roadside Device Status:** Current message and status of Highway Advisory Radios (HAR) and Variable Message Signs (VMS) deployed across the state. Plans are underway for the statewide networking of HAR, which would facilitate the recording and updating of messages.
- **Commercial Vehicle Operations (CVO):** CVO data includes permit status and data collected at weigh stations. With the increasing need to monitor and track freight for both security and operational reasons, CVO-related data is likely to increase.

[2] The Northwest Region has begun posting small video clips on-line in addition to snapshot video. These video clips require additional bandwidth.

- **Condition Acquisition and Reporting System (CARS):** Incident data entered into the CARS system by TMC and maintenance staff, is accessible to authorized users across the state. CARS will be linked with the Washington State Patrol's CAD system.

Currently, there is little region-to-region coordination/control of ITS devices. The primary exceptions are:

- **Hyak Pass**: North Central region operates the majority of the devices and Northwest region operates the remainder (with some cross over) and;

- **Between North Central and South Central:** Since North Central region does not have a true TMC, South Central acts as the TMC for both regions, and controls all of North Central's devices during off hours.

It is likely that the current extent of region-to-region ITS coordination/control may increase as more devices are deployed along regional boundaries, and as more opportunities for cooperation between regions develop. This is discussed below in Section 3.1.5 on Growth.

At this time, WSDOT is seriously considering the development of a Statewide Traffic Operations Center/Emergency Operations Center (STOC/EOC) to be located in the vicinity of Olympia Headquarters. The purpose of the STOC/EOC would be to consolidate and integrate statewide traffic monitoring, device control, and information dissemination. The potential functions of the STOC/EOC and the likely associated growth of network traffic are discussed in more detail in Section 3.1.5.

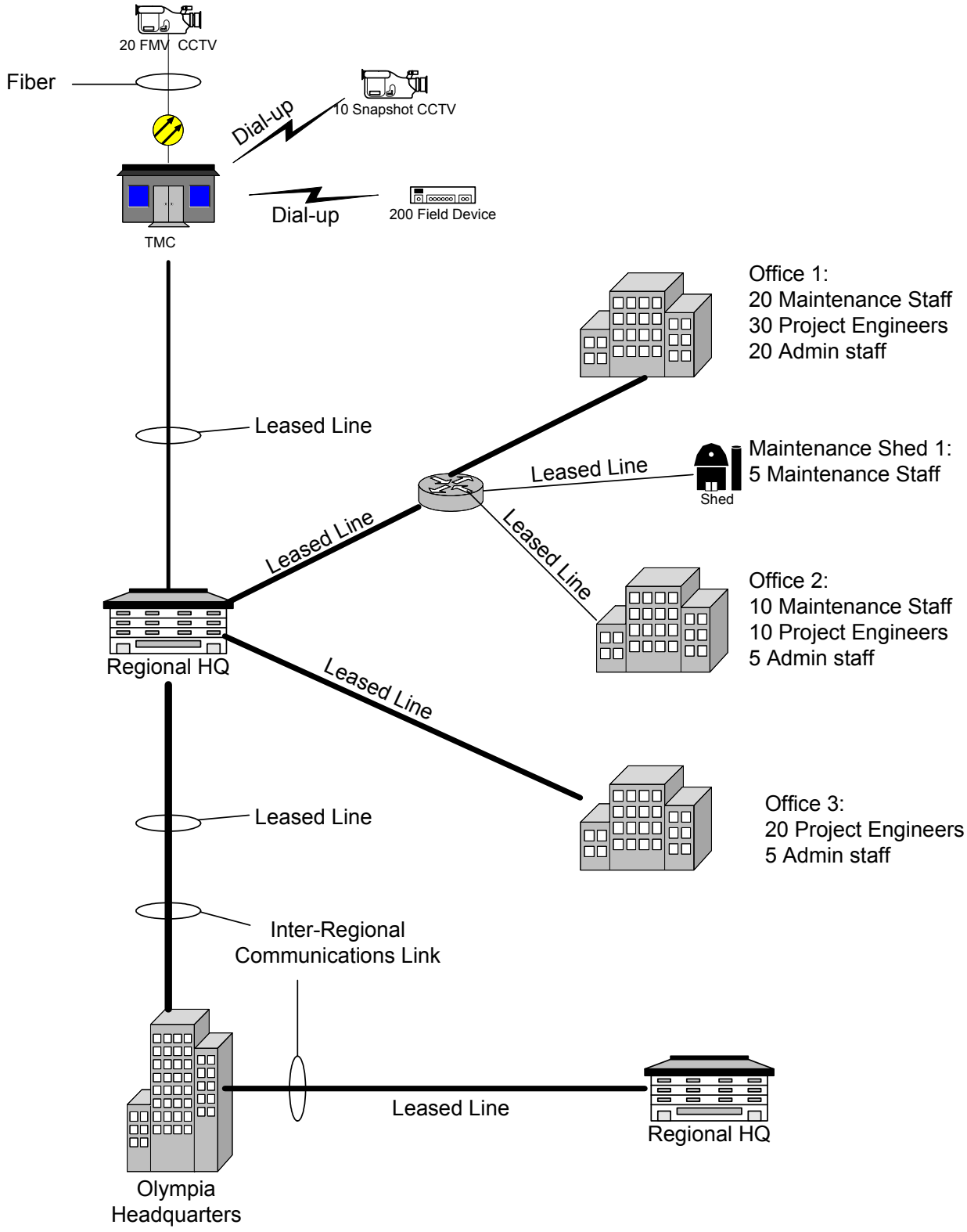


Figure 4: Example Star Topology from Region to Olympia HQ

3.1.3 Utilization

WSDOT's Office of Information Technology (OIT) does an excellent job of monitoring the utilization of all WSDOT data links, by remotely polling utilization records from the routers. Using this data, OIT develops bandwidth utilization charts to illustrate network usage, identify potential "choke points" (or heavy utilization segments) and proactively manage the network.

Figure 5 is an example of a bandwidth utilization chart from WSDOT OIT. This chart is displaying the average daily usage of the point-to-point T1 link between the Yakima Regional HQ and Olympia HQ offices for the month of October 2002.

At the top of the chart is the link identification tag (name of the segment). This tag identifies the routers on each end of the link. Directly below the tag is the bandwidth size indicator (note 1.544 Mbs indicates a full T1.) The chart itself shows time (in days) as the horizontal (-x) axis and bandwidth utilization as a percentage of the full 1.544 Mbs as the vertical (-y) axis. The average utilization for each day is shown.

As bandwidth utilization increases, the number of data collisions or bit errors increases accordingly, creating network slowdowns and occasionally, lost data. The following are some very general rules of thumb for bandwidth utilization:

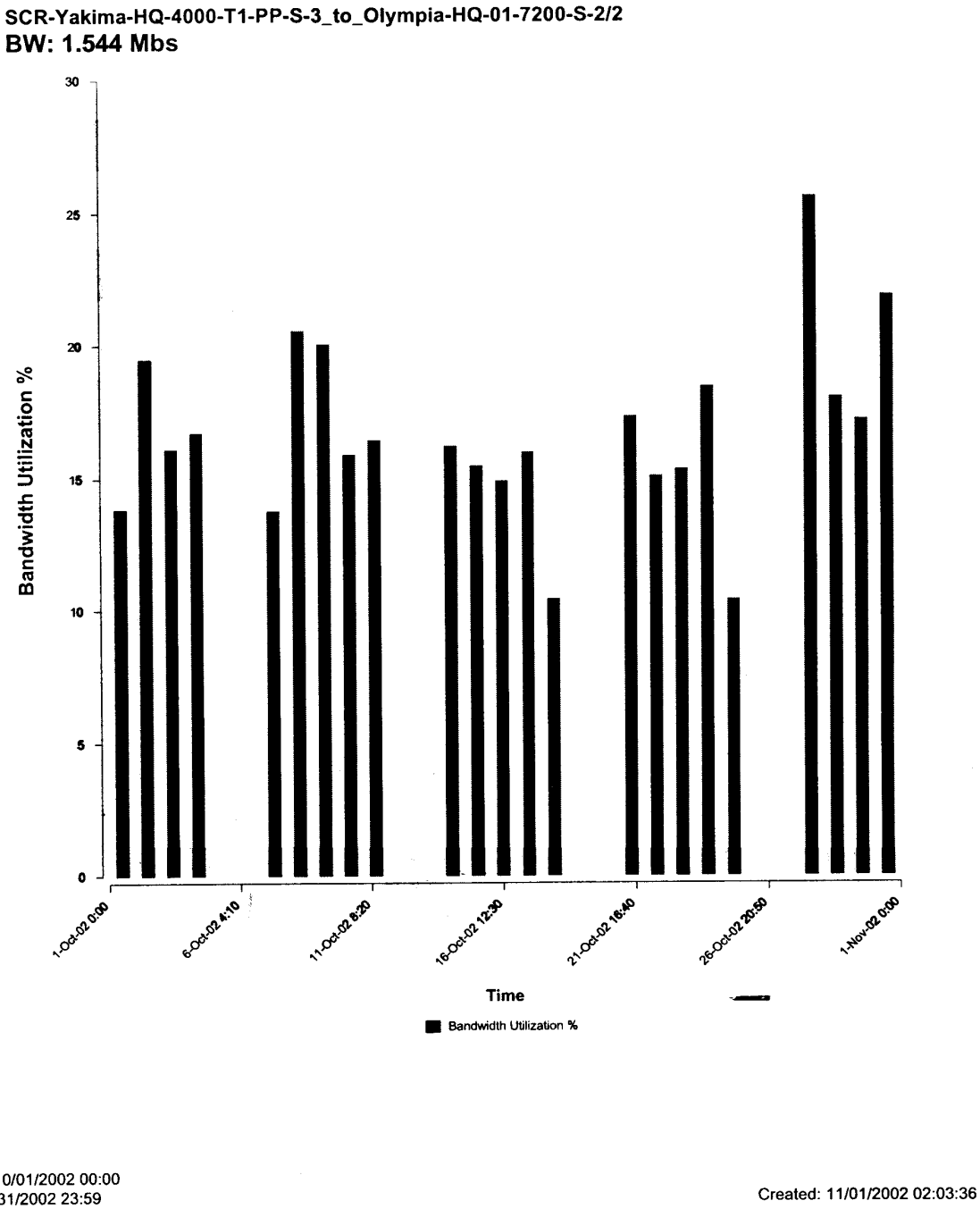
- **Less than 20% Utilization**: Should not experience notable system slowdown.
- **20-30% Utilization**: Will start noticing periodic system slowdown and may consider upgrading link bandwidth or other action[3] to reduce utilization percentage.
- **Greater than 30% Utilization**: Will likely notice regular system slowdown and occasional lost data; should consider upgrading link bandwidth or other action to reduce utilization percentage.

Figure 6 is a chart indicating the bandwidth utilization of all of the Inter-regional Leased Line Connections, again using data from the month of October 2002. The chart shows the range of daily utilization levels that were observed throughout the month. As can be seen, only the Wenatchee HQ to Olympia HQ segment currently exceed the 20% utilization "barrier"; but the Tumwater HQ, Spokane HQ and Yakima HQ are all very close to this threshold and will likely exceed it in the near future.

[3] "Other action" may include implementing an alternate or redundant route, utilizing a different technology such as fiber or wireless communications, or changing the topology of the network.

South Central Region Trend Report

Normal Work Hours Only



From: 10/01/2002 00:00
To: 10/31/2002 23:59

Created: 11/01/2002 02:03:36

Figure 5: Example Bandwidth Utilization Chart

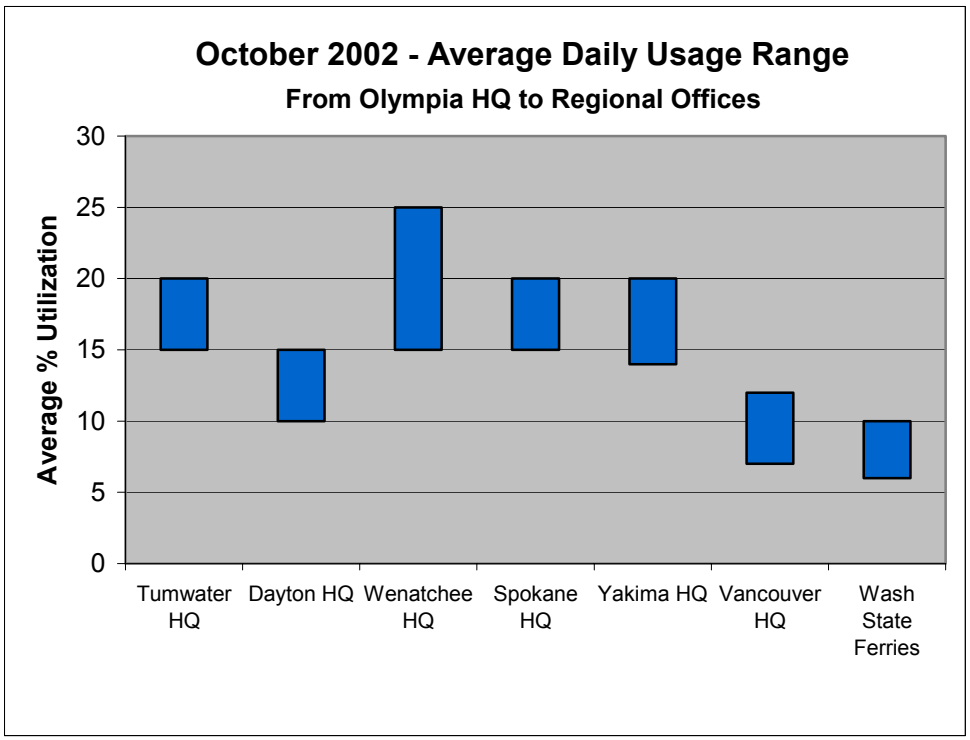


Figure 6: Bandwidth Utilization of Inter-regional Connections

3.1.4 Planned Upgrades

As discussed above, some of the Leased Line segments were identified during the interviews to have a different total available bandwidth than the segments identified in Figure 2[4]. The interviews indicated that upgrades are planned for the following two segments and it is possible these upgrades may already have taken place:

- **Tumwater HQ to Olympia HQ**: The planned upgrade is for two T1s for data and a third T1 for voice communications. If the upgrade is already in place, this may account for why this connection is currently below the 20% utilization threshold.

- **Vancouver HQ to Olympia HQ (Leased Line):** The planned upgrade is for two T1s on this link. As above, the presence of a second T1 (if already in place) may account for why this connection is currently well below the 20% utilization threshold.

- **Vancouver HQ to Olympia HQ (Microwave):** In addition to the two leased-line T1s, there is a third T1 between Vancouver and Olympia that is utilizing the WSDOT/WSP jointly-owned microwave network. At the time of the interviews, this link was in "test

[4] Note: WSDOT OIT updates these Network Architecture schematics regularly. Some of these upgrades may have already been identified in recent updates.

mode" but has since been migrated to a fully operational data link. This will be discussed in more detail in subsequent sections.

- **Quest 100Mbs Upgrade:** Subsequent to the interviews, WSDOT has continued to pursue opportunities to upgrade several leased line communications links. Through continued negotiations with Qwest, WSDOT is planning on upgrading links between WSDOT HQ in Olympia, Dayton (NW Region HQ and TMC), Ecology, CAE, the Materials Lab, Olympic Region HQ and the Tacoma TMC all to dedicated 100Mbs connections.

- **NoaNet 100 Mbs Upgrade:** Subsequent to the interviews, WSDOT has continued to pursue opportunities to upgrade several other leased line communications links. Through negotiations with NoaNet, WSDOT is planning on upgrading links between WSDOT HQ in Olympia, Wenatchee (NC Reg. HQ), Spokane (Eastern Reg. HQ), Yakima (SC Reg. HQ), Vancouver (SW Reg. HQ) and the WSF HQ all to a shared 100Mbs ring (through Portland, OR) on the NoaNet backbone.

See Figure 7 for a schematic illustration of the planned Qwest and NoaNet upgrades described above. These upgrades will be able to support improved data connections, provide higher quality video conferencing service, add phone lines (through packetized T1s for PBX links) and allow continued deployment of Voice over IP for phone service. It is envisioned that WSDOT will have increased focus on utilizing video conferencing to minimize travel costs, particularly once these upgrades are in place.

These new routes will bring additional redundancy (both carrier and physical entry into the building) into the WSDOT HQ building.

Completion of these upgrades is also contingent on finding "last mile" solutions in each of the markets. In many cases, this is the responsibility of the telecommunications provider, however, in some markets (including City of Seattle, City of Spokane and City of Vancouver) local municipalities of constructed their own fiber networks. In each of these areas, negotiations are underway with local municipalities to determine if they may be able to provide an acceptable and more cost effective last mile solution.

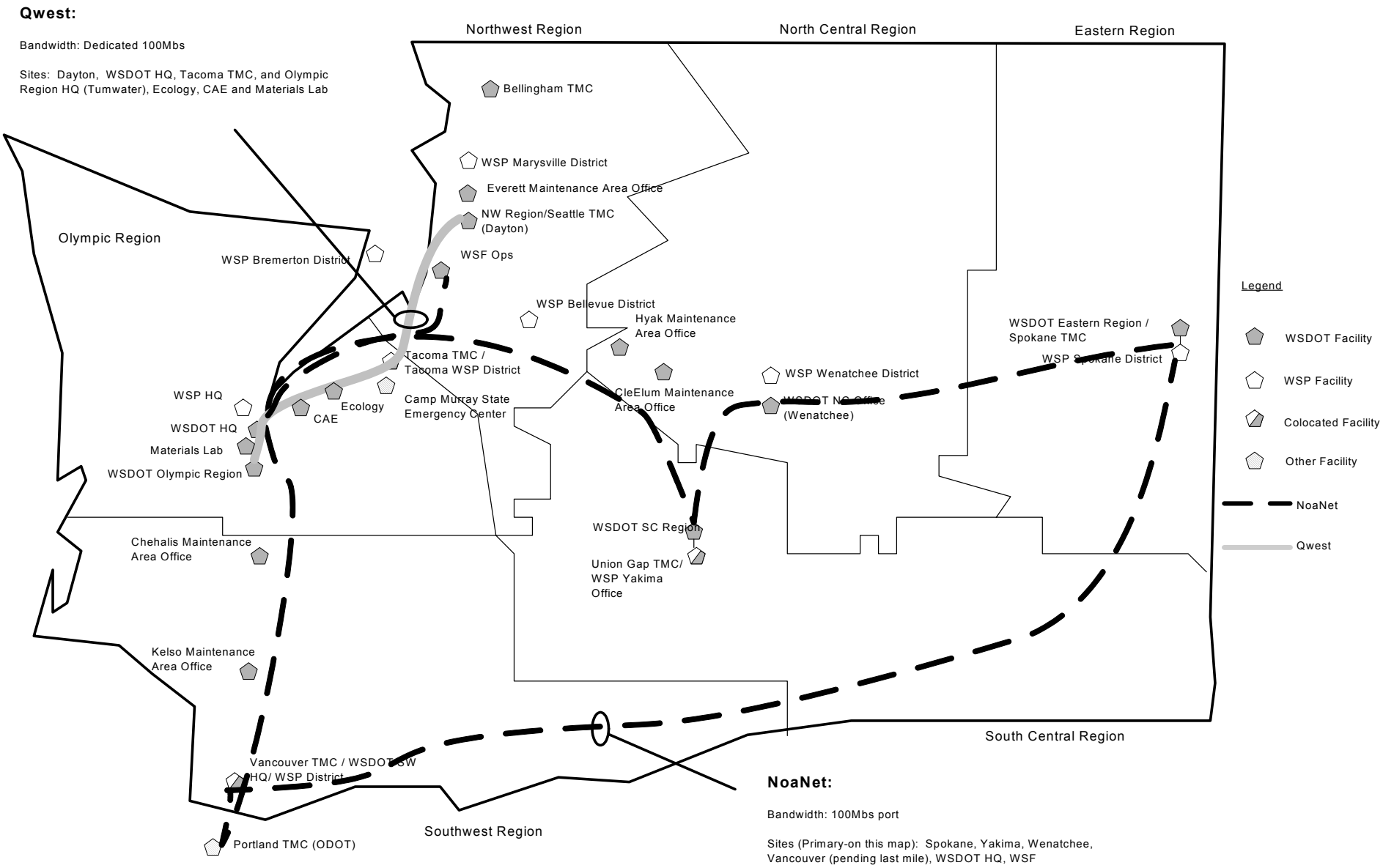


Figure 7: Planned Qwest and NoaNet 100Mbs Upgrades

3.1.5 Growth

3.1.5.1 Enterprise/IT

As a general rule, bandwidth requirements of nearly any enterprise tend to increase over time, assuming other factors stay relatively constant (number of employees, offices, etc.). This is due to a number of factors – including issues such as increasing numbers of people becoming familiar with, using, and even becoming dependent on, the use of email and the Internet. There is also generally increasing use of other on-line internal and external applications, and many organizations are developing (and encouraging the use of) their own on-line applications, such as time sheets and reports.

It is important to note that because Referendum 51 failed to pass, WSDOT is projecting the need for some significant staff reductions under the current law budget. While it is impossible to predict the exact impact on communications requirements at this point, it is likely that there will be an associated leveling off (or even a short-term reduction) in network utilization and associated bandwidth requirements. However, it is anticipated that this shorter-term reduction in usage will at some point be outweighed by the normal increases in network utilization and the issues discussed below.

The network upgrades discussed above are expected to significantly improve the operation of the video conferencing system. Subsequently, it is anticipated that use of the video conferencing system is expected to grow, particularly in the impacted offices.

There are a number of specific trends at WSDOT that will continue to drive bandwidth requirements up, in addition to the general increase discussed above. The following are some examples (not all-inclusive) of driving forces that will likely increase bandwidth requirements:

3.1.5.1.1 Centralization of Applications

There has been an increasing trend at WSDOT towards the centralization of applications. The current Secretary of Transportation, Doug MacDonald (who took office in Spring of 2001), has placed an increased emphasis on performance measuring throughout the agency. The Secretary's office produces the quarterly performance measure report: *Measures, Markers and Mileposts* (known informally as "The Gray Notebook"). In order to efficiently collect the data required for this and other reporting mechanisms, more and more applications are being developed by WSDOT, whereby field personnel can prepare reports on-line while the application itself is running from a centrally located server (either at the regional HQ or at Olympia HQ). Maintenance, Operations, Inventory, Engineering, Administration, and Incident Response are some of the departments that are currently, or soon will be, utilizing these applications.

As each new application becomes centralized, it puts an increased strain on the network segments between the individual using the application and the server where the application is housed. This strain is particularly great when larger-size files are attached or included in the application, such as CAD drawings, digital photos, SR View images, etc.

This trend towards centralization of applications appears likely to continue and is supported at all levels.

3.1.5.1.2 "Big Bandwidth" Applications

There are a number of "big bandwidth" applications being used by WSDOT, most notably SRview, which runs on the WSDOT intranet. SRview allows the user access to digital images of Washington's highway system in increments of 1/100 of a mile. WSDOT has developed SRweb for external use, whereby the information and images available in SRview are available to outside users via the Internet and browser software. The most notable difference between SRweb and SRview is that SRweb requires manual advances to view the images.

SRview runs over the network, therefore whoever is accessing SRview images is actually accessing them from the server where they are located, whether that be at a regional office or at Olympia HQ. All of the network segments between the user and the server are then impacted. A large volume of digital information is transferred, so the application requires "big bandwidth" between the server and user to function.

In addition to SRview, there are a number of design and engineering applications which can be heavy bandwidth users, including CAICE, Microstation CAD, GIS, and aerial photography, just to name a few. Design techniques are becoming increasingly complex and often designers are layering images from one application on top of another. For example, a designer might start with an aerial photograph, overlay a CAD drawing, and then overlay GIS data. This impacts network utilization in two ways. First, when users access data from an online server, they are utilizing network links between that user and the server. Second, once the design drawings are completed, they are often sent via email to several other colleagues or external entities. Emailing such large files impacts the network as well.

3.1.5.1.3 Digitizing of Construction Documents

One of the other trends that was discussed during the interviews was the possible decision to digitize and store all construction documentation, including construction drawings, contracts, submittals (as applicable), change orders, RFIs, correspondence, etc. This would include any new major construction project (which admittedly will be minimal for the foreseeable future with the failure of Referendum 51), but also any maintenance projects which require construction documentation (which will continue). This directive may also be somewhat retroactive with construction projects that have already been completed.

The uploading of such construction documents from the field to file servers located at Olympia HQ would have some bandwidth implications. It is not clear at this point if a policy will be implemented to ensure that such files are only downloaded in off peak periods. Also, what is not clear at this point is if and how these documents are intended to be accessed in the future. For example, if the intent is for them to be called up and viewed remotely, additional bandwidth impacts may continue beyond the initial upload.

3.1.5.2 ITS

The growth in ITS bandwidth requirements is more directly related to the number of devices deployed in the field, how often they are polled and the way that they are utilized. As discussed, video is often the largest user of available bandwidth. The CCTV camera images have proven to be very effective for incident verification and management and are very popular traveler information sources (via the Internet). This program is likely to continue to grow, with additional cameras being deployed throughout the state. This will impact inter-regional communications requirements in a number of ways:

- **Increased number of images**: To be backhauled from the device, to the regional TMC and on to Olympia to be posted on the web,

- **Increased desire for inter-regional coordination**: As CCTV cameras are deployed near regional boundaries, neighboring regional TMCs may want to have viewing and possibly control capabilities of each other's cameras. In addition to CCTV cameras, neighboring regions predict a growing desire to have access to (and in some cases control of) HAR and VMS messaging in neighboring regions.

- **Possible usage of full motion video**: The Northwest region's display of video clips (in addition to still images), is in response to what many system users have requested, i.e., better information. Full motion video (or even limited video clips) gives the user a better sense of true traffic flow conditions. However, it also has extremely significant impacts on bandwidth utilization. If the trend continues towards providing more full motion video, bandwidth impacts will need to be looked at closely.

As discussed previously, in addition to video images, there are significant volumes of data being sent to Olympia for field device data storage, application, and even for posting on the Internet. Again, as more devices are deployed, bandwidth requirements will increase. Additionally, some new applications may require more frequent polling of device data. Whenever this is the case, bandwidth impacts will be felt.

Finally, the biggest potential ITS development that could have serious inter-regional bandwidth implications is the proposed Statewide Traffic Operations Center/Emergency Operations Center (STOC/EOC). Appendix A includes a brief description of the proposed STOC/EOC, including Possible Functions, Operations Scenarios, Center Layout and Space Requirements. To summarize this Appendix, the possible functions of the STOC/EOC include:

- **Monitoring Existing Web and Media Information**: Requiring the STOC/EOC to have access to all of the information currently available on WSDOT's website, as well as access to other information providers, such as the media, statewide.

- **Integration of Other Data Sources**: Some data sources, such as the TDO data stations and CVO transponders and tags, are not currently being used for operations or travel time data. To make use of these, special applications, and links to the field devices will have to be developed.

- **Statewide Monitoring and Management of HAR, VMS and CCTV**: Statewide monitoring of HAR may be an extension of the statewide HAR network project (currently underway), while potential statewide monitoring of VMS and CCTV would be an entirely new endeavor.

- **Emergency Response Operations**: the STOC/EOC could become the new WSDOT HQ Emergency Operations Center (EOC) and would be the location where WSDOT coordinated with other agencies, local municipalities, WSP, etc, in times of significant events with a large geographic impact.

While the functions and applications of the proposed STOC/EOC are still in the very preliminary planning stages at this point, it is apparent that any STOC/EOC could have significant bandwidth requirements from linking each of the regional TMCs back to Olympia HQ, as well as to other emergency providers such as WSP.

3.2 INTRA-REGIONAL COMMUNICATIONS

Intra-regional communications include the various video, voice and data connections between facilities located within a given WSDOT region. This includes WSDOT office-to-office communications, as well as communications with any other agency, including WSP, local municipalities, emergency service providers, etc.

3.2.1 Existing Infrastructure and Architecture

3.2.1.1 Leased Line

Figure 8 through Figure 14 are the Network Architecture diagrams provided by WSDOT OIT for each of the six WSDOT regions and WSF. As with the inter-regional connections, these include point-to-point T1s and frame relay T1s, however, there are also segments of fiber build between several offices and 56K dial-up at several of the smaller offices (generally maintenance sheds.) Often times, one or more of the sites in the Frame Relay "cluster" are much larger than the other sites or at least have higher bandwidth requirements, due to the nature of the facility. If one of the sites in the "cluster" is such a high bandwidth user that it causes a network slowdown, the other sites will experience the slowdown as well. The purpose of identifying the individual high bandwidth segment is to indicate which leased line segments would bring the biggest benefit if upgraded or replaced by either microwave or fiber connections.

The overall architecture is a star configuration, where the majority of offices have a connection to the Regional HQ. There are a small number of offices that link to the Regional HQ through another office. Voice and data traffic between the local office and Olympia HQ travels over the intra-regional communication network to the Regional HQ and then over the inter-regional network to Olympia. Communications traffic between regions from a local office also follows this path to Olympia, where it is routed to the destination in another region. Figure 15 illustrates the same intra-regional connections in geographic format, using the Eastern Region as an example. Again, this map was generated from the GIS database developed specifically for this project. The data is available in this database to generate similar maps for each region as required

by WSDOT. The entire statewide network (including all sites within each region) has been mapped and included as an attachment to this report.

Again, each of these T1 or 56K connections is leased at varying monthly rates from a private telecommunications service provider. The fiber is owned and maintained by WSDOT.

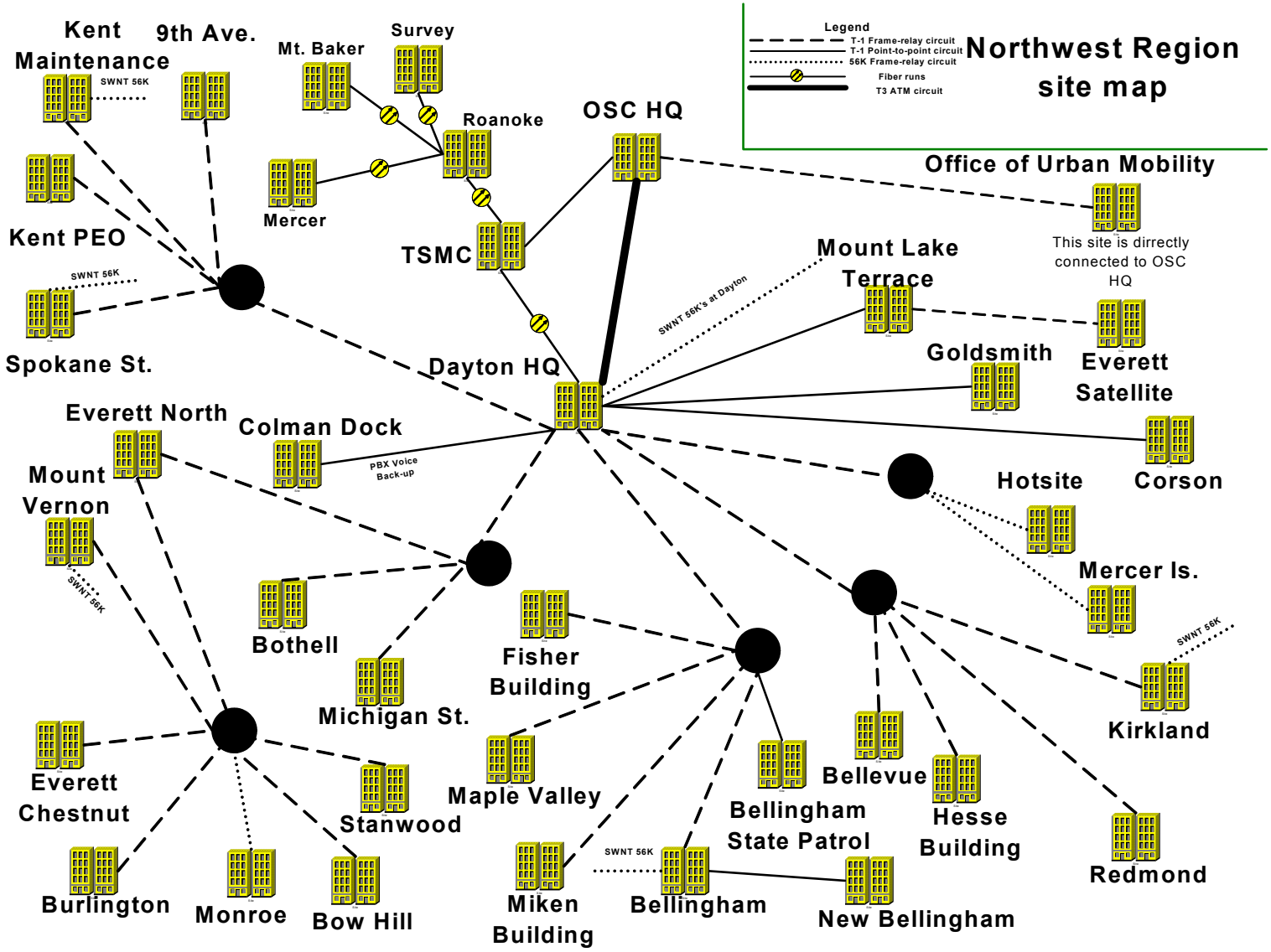


Figure 8: Northwest Region Leased Line Network

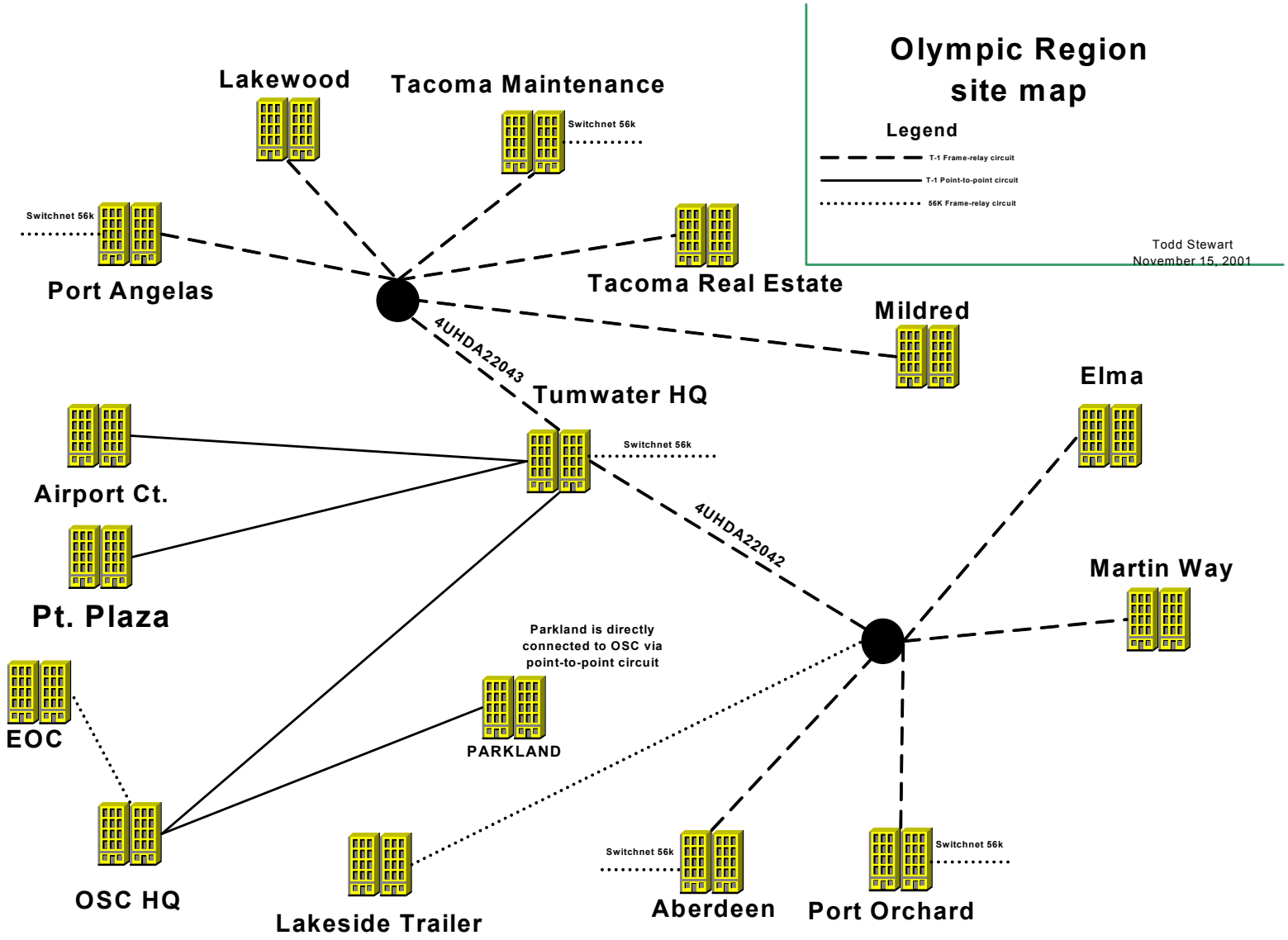


Figure 9: Olympic Region Leased Line Network

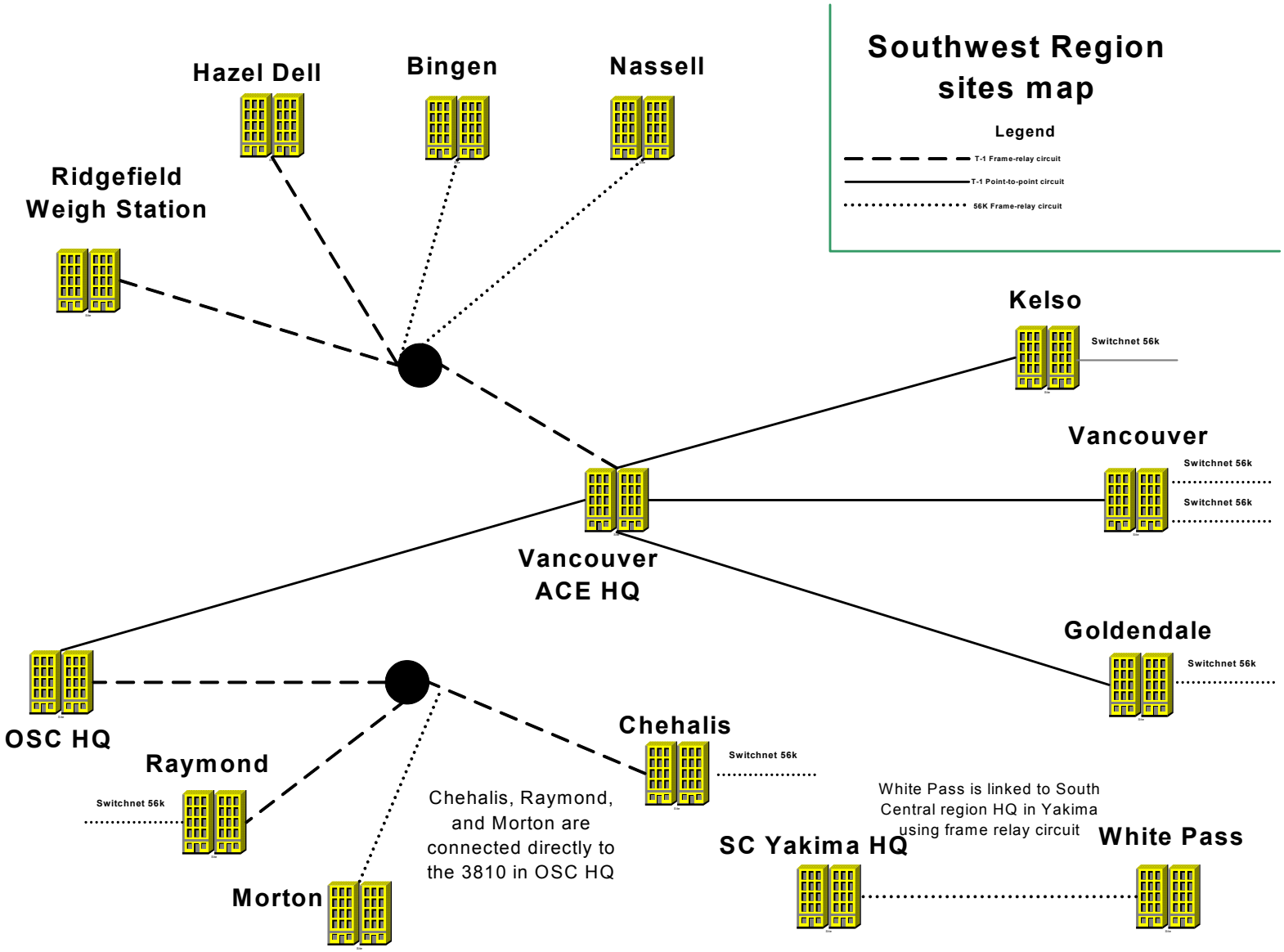


Figure 10: Southwest Region Leased Line Network

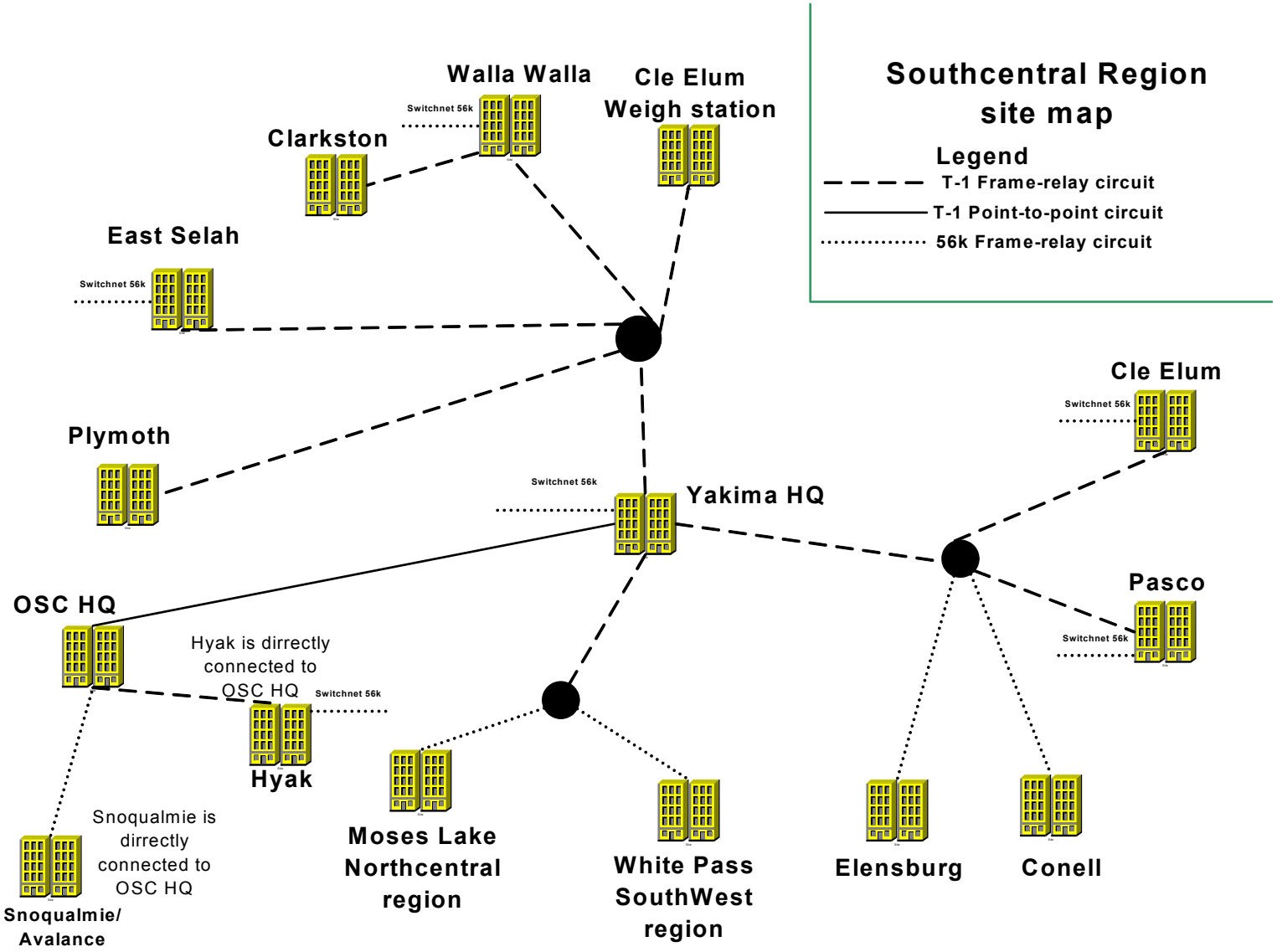


Figure 11: South Central Region Leased Line Network

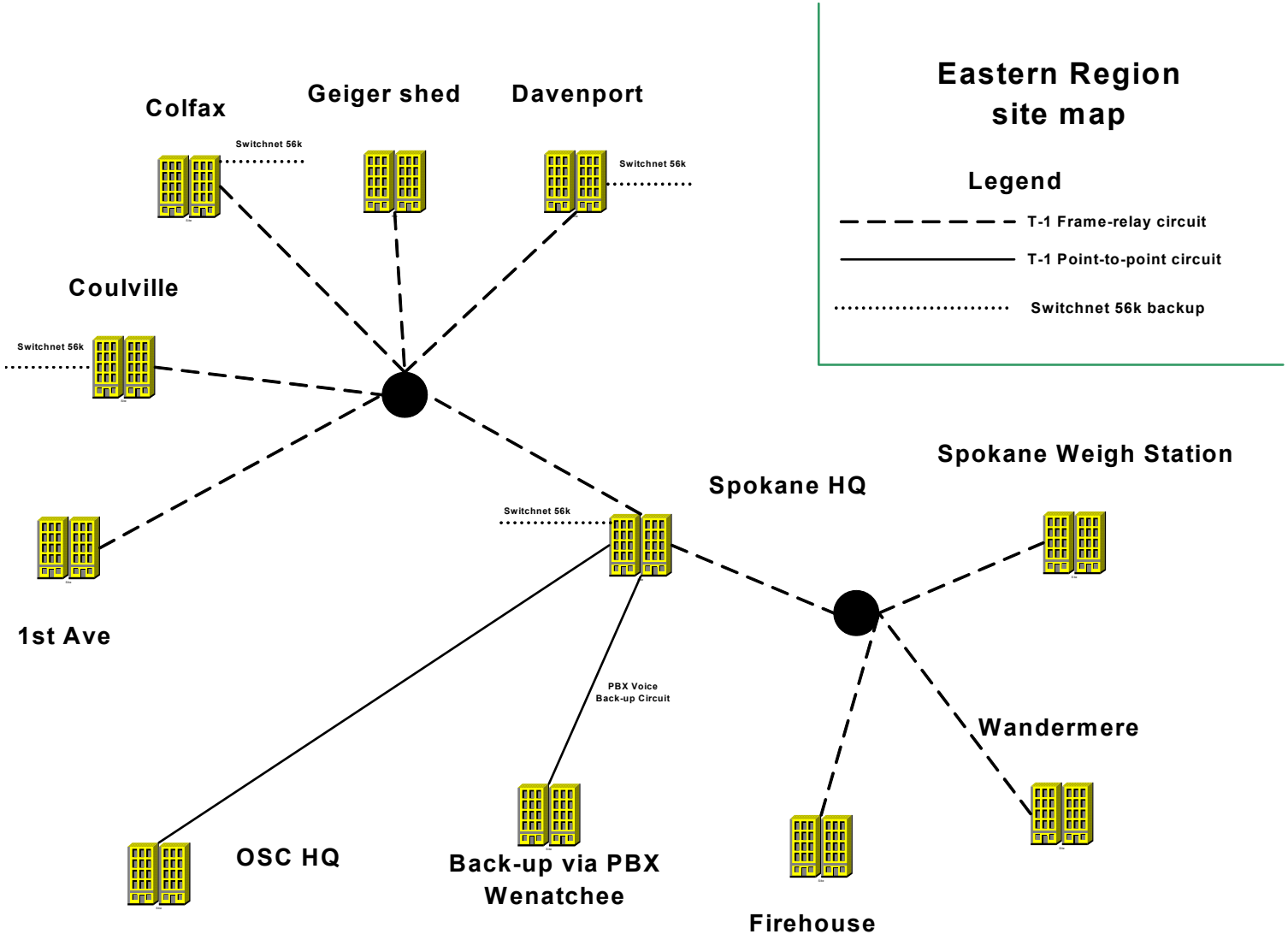


Figure 12: Eastern Region Leased Line Network

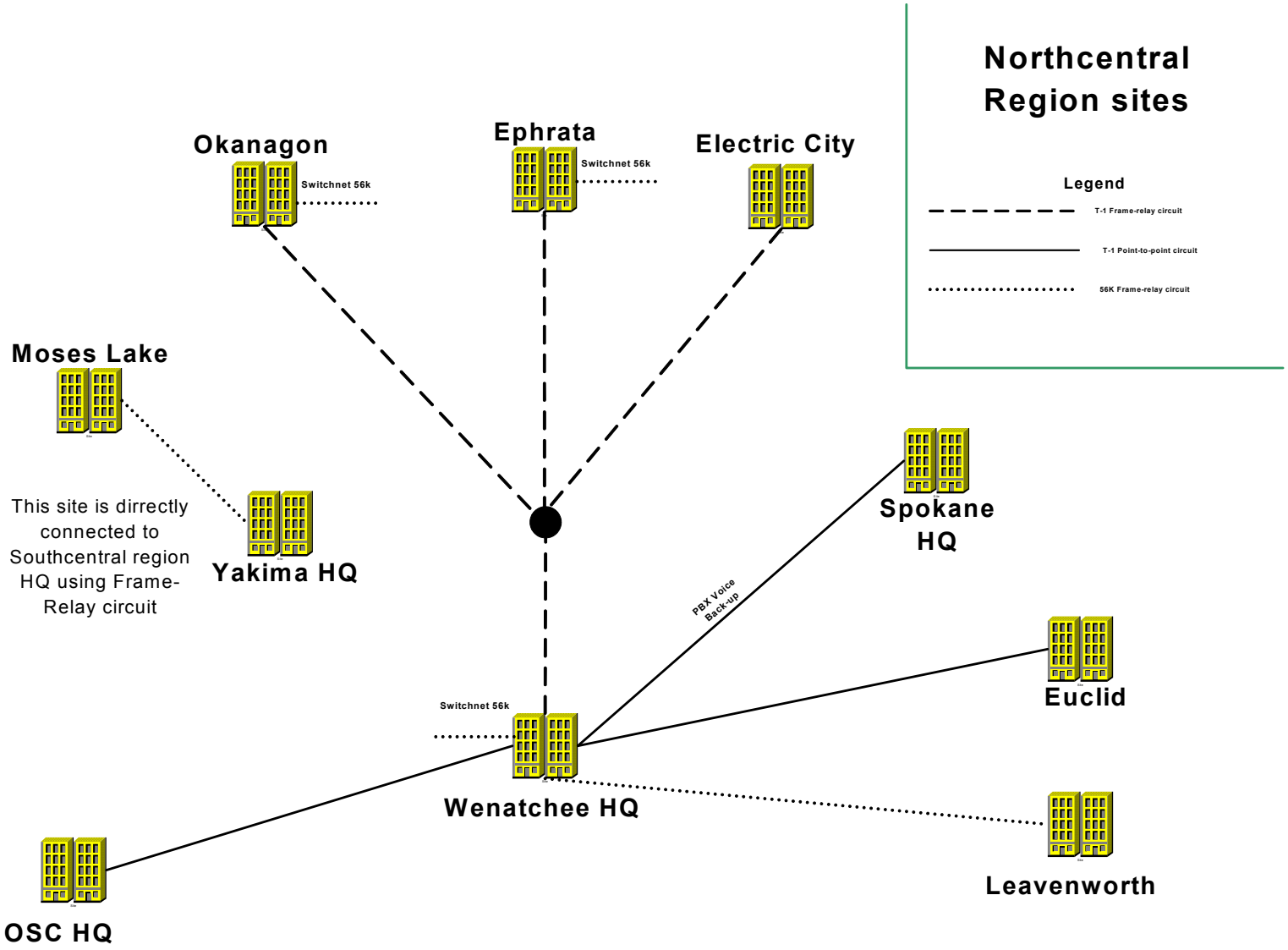


Figure 13: North Central Region Leased Line Network

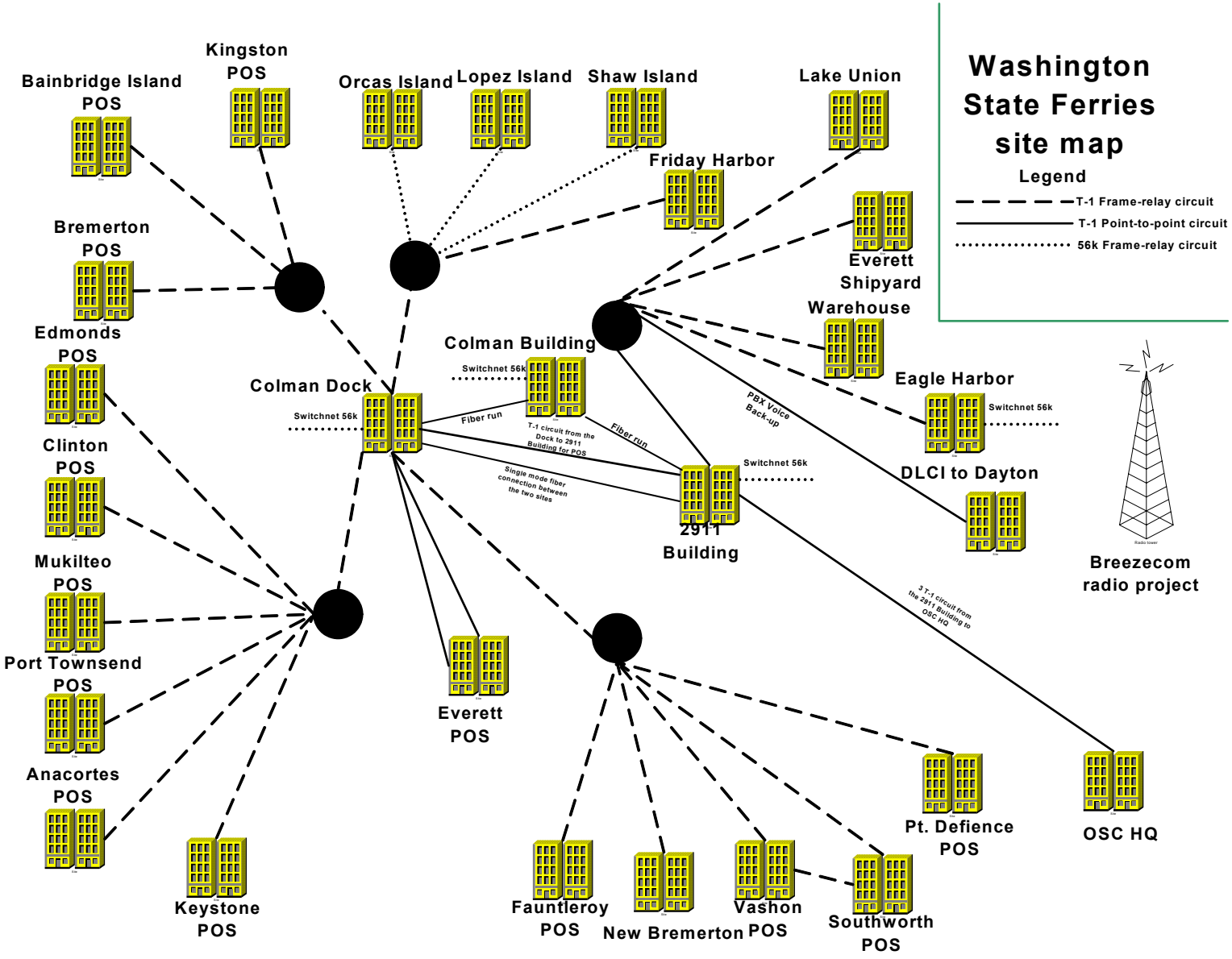


Figure 14: Washington State Ferries Leased Line Network

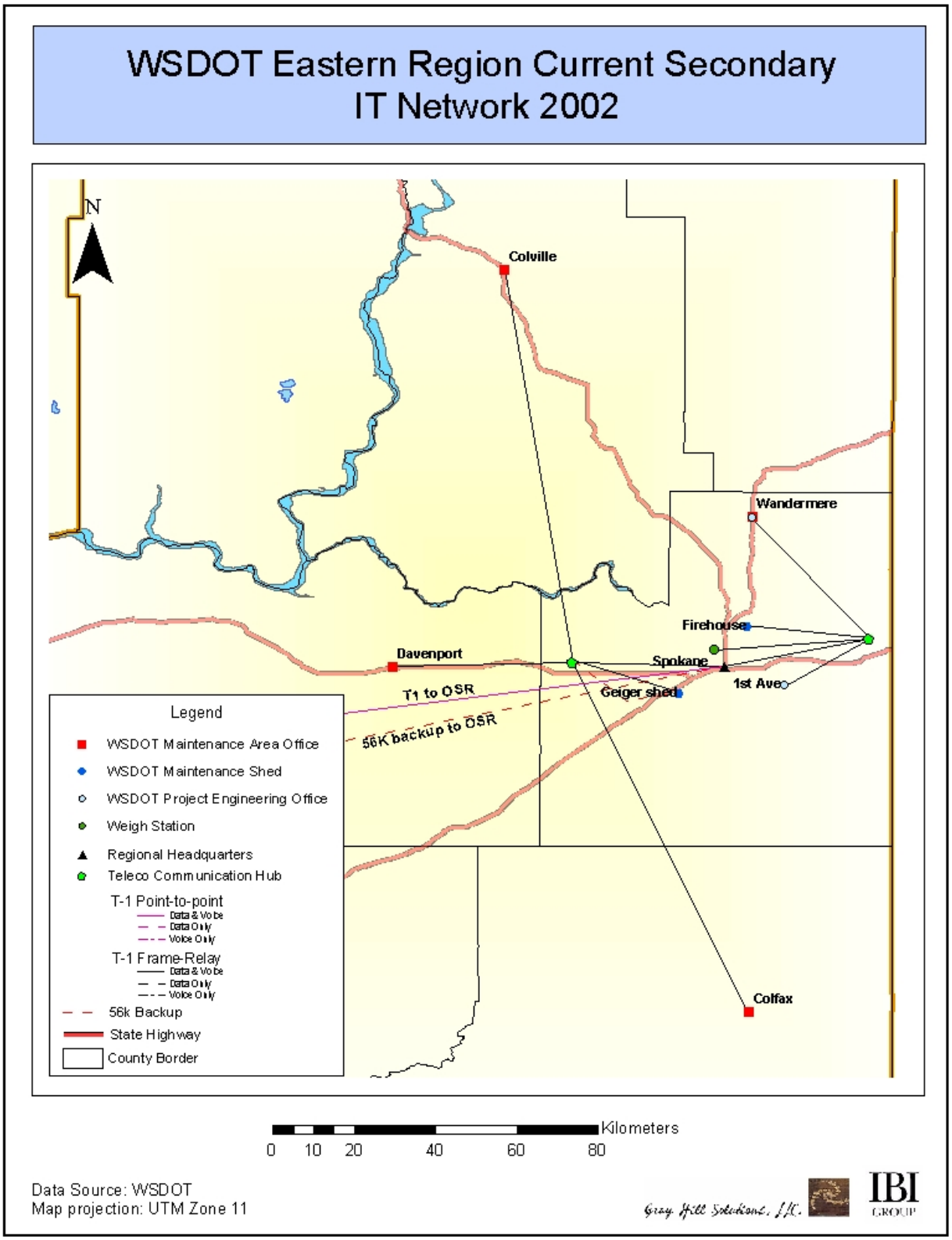


Figure 15: Example Regional Leased Line GIS Output

3.2.1.2 Fiber

In addition to the fiber shown in the above figures, some of the regions have built ITS fiber segments, or in the case of Northwest Region, an entire fiber ring. Currently, these fibers are generally used exclusively by the regional TMC to communicate with ITS field devices, including CCTV cameras, as well as low speed data devices such as VMS, traffic count stations, RWIS, etc. However, recent discussions have included analyzing the possibility of using this fiber (in special situations) for data connections between other WSDOT facilities.

Every region except for North Central includes some fiber optic cable (South Central's fiber network is limited to connecting two buildings across the street from one another.) This fiber is generally owned and maintained by WSDOT, with the exception being the Olympic Region, who built their fiber network around downtown Tacoma as a joint project with Tacoma City Fire Department. WSDOT owns half of that network's fiber.

3.2.1.3 WSF 802.11 Pilot Project

Washington State Ferries (WSF) has deployed 802.11 technology (commonly referred to as WiFi) on several of their vessels to track vessel location, real-time diagnostic/maintenance information and even voice communications with ferry operators. This implementation is still in pilot project mode while security issues are being worked out.

3.2.2 Communications Traffic

The types of video, voice and data traffic on the intra-regional communications network are identical to those described in Section 3.1.2 on the inter-regional network.

3.2.3 Utilization

As with the inter-regional links, WSDOT OIT tracks bandwidth utilization for all of the intra-regional links by remotely monitoring the routers and producing bandwidth utilization charts for each. For the purposes of this report, any segment that showed frequent occurrences of over 20% bandwidth utilization was considered a "high utilization segment."

Figure 16 indicates all of these intra-regional high utilization segments. As with the inter-regional connections, in developing this chart the high and low days of each month were discarded and the chart displays the range of usage for the remaining days.

The same general rules of thumb for bandwidth utilization apply, including:

- **Less than 20% Utilization**: Should not experience notable system slowdown
- **20-30% Utilization**: Will start noticing periodic system slowdown and may consider upgrading link bandwidth or other action to reduce utilization percentage
- **Greater than 30% Utilization**: Will likely notice regular system slowdown and occasional lost data; consider upgrading link bandwidth or other action to reduce utilization percentage

Almost all of these over-utilized segments are cases where multiple sites are sharing a frame relay T1 connection. What is important to note, is that in most of these cases, only one or two of the sites are "large" sites (i.e., heavy bandwidth users). However, when the network connection becomes slowed down, all of the sites on the shared T1 will experience network slowdown. The approach that has been used in dealing with these segments is to trim out the high bandwidth office from the frame relay cluster and provide a dedicated leased line for this office. This provides increased capacity for the office and to the other cluster members.

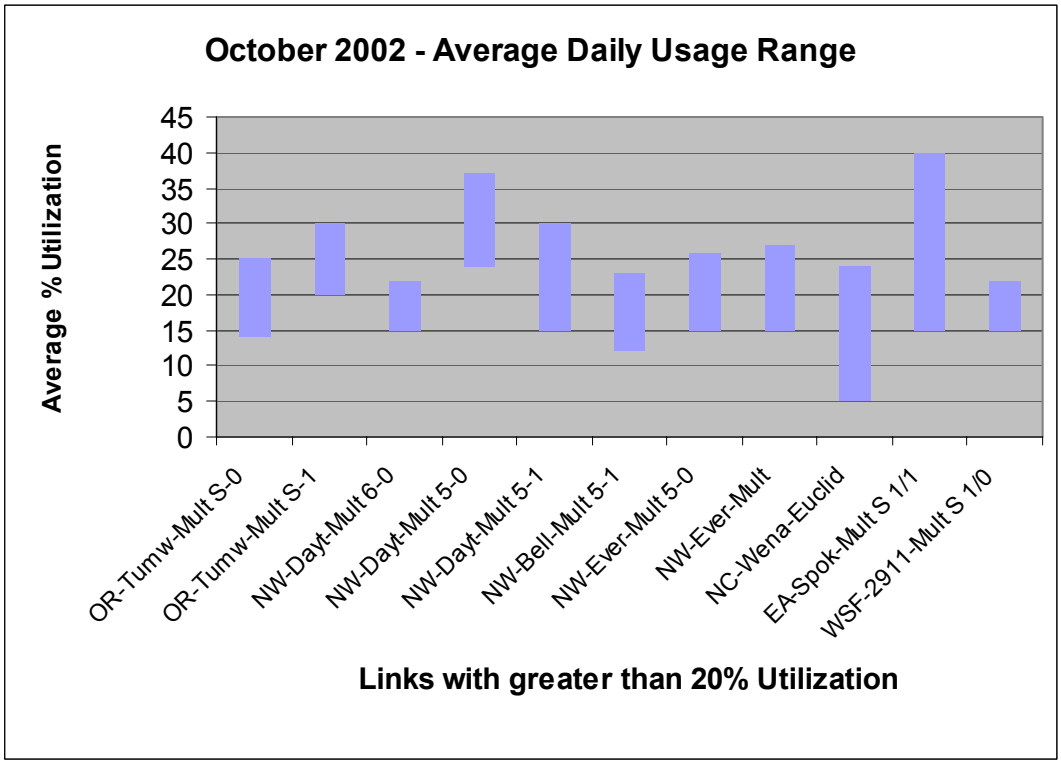


Figure 16: Intra-regional High Utilization Segments

3.2.4 Planned Upgrades

3.2.4.1 Enterprise/IT

As with the inter-regional communications links, there were several segments identified that may have different bandwidth links as compared to those illustrated in the network architecture schematics[5]. Therefore, many of these upgrades listed below may have already been implemented. These upgrades include (by region):

[5] Note: WSDOT OIT updates these Network Architecture schematics regularly. Some of these upgrades may have already been identified in recent updates.

Northwest Region

- **Dayton HQ to Corson**: Planned upgrade would include two T1s on this link.

- **Dayton HQ to Office of Urban Mobility**: Planned upgrade includes a direct T1 link between these two offices that is not indicated in Figure 8.

- **Dayton HQ to 'El Capitan' (shown on map as Everett Satellite)**: NW region IT is working together with the ITS group to investigate connecting these buildings using the ITS fiber ring, as opposed to (or in addition to) the leased line connection. The frame relay connection to Everett and other northern sites is one of the most heavily utilized connections in WSDOT's entire network. Figure 8 shows this as the connection between Dayton HQ and Everett North, which is shared with several additional sites. Migrating the connection to Everett Satellite to fiber, and then switching the leased lines up to Mt. Vernon (and other northern sites) would not only help network performance between Dayton HQ and Everett, but also to all of the sites sharing this connection.

Olympic Region

- **Tumwater HQ to Pt. Plaza**: Planned upgrade includes two T1s on this link, as opposed to the single T1 indicated in Figure 9.

- **Mildred Eng Office to Center Street Real Estate Office**: Planned upgrade includes one (or possibly two) T1(s) between these facilities. The Center Street Real Estate Office is not shown in Figure 9.

- **Mottman Bridge Preservation Office and Mottman Maintenance Shed**: Planned upgrade includes a T1 connection between the Olympia HQ and Mottman Bridge Preservation office (possibly illustrated in Figure 2) and both a fiber (for data) and a copper (for voice) connection between the Mottman Bridge Preservation Office and the Mottman Maintenance shed.

- **Future Gig Harbor Site**: A new site in Gig Harbor is planned to come on-line in early 2003 for the Tacoma Narrows Bridge. Bandwidth requirement has not been identified.

Southwest Region

- **Vancouver HQ to Kelso**: Planned upgrade includes two T1s on this link.

- **Vancouver HQ to Vancouver Office**: Planned upgrade includes two T1s on this link, as opposed to the single T1 indicated in Figure 10.

- **Hazel Dell Site**: Interview indicated that this site is no longer utilized by WSDOT, however, the Frame Relay T1s are still be used by remote CCTV cameras.

It was also noted in the Southwest Region interview that all of the T1s currently have a 56K back-up, which is being eliminated with no alternate back-up currently identified.

South Central Region

- **Yakima HQ to Ellensburg:** Interview indicated that the 56K frame relay connection illustrated in Figure 11 would likely be upgraded to a broadband connection in the near future. The upgrade could be a DSL or cable modem connection, depending on availability and pricing from local service providers.

Eastern Region

- **Remote Maintenance Sheds**: Planned upgrade includes up to 16 maintenance sheds (none of which are indicated in Figure 12) being added to the network in the near future and will utilize satellite broadband connections. At the time of the interview, WSDOT was testing these satellite broadband connections at several sites, but has since decided to proceed with full-scale deployment.

  Eastern Region had looked into other options for replacing the dial-up service to these maintenance sheds (many of which were at 24.4k speeds), but found that in most cases satellite broadband was the only option. Rather than split their network between some DSL, some cable broadband and some satellite, they decided to standardize as much as possible with one vendor and one solution.

North Central Region

- **Wenatchee HQ to Euclid**: Planned upgrade includes two T1s on this link, as opposed to the single T1 indicated in Figure 13.

- **Electric City to local ISP**: Interview indicated that the North Central IT staff is looking into connecting the Electric City facility to a local Internet Service Provider (ISP) using fiber being constructed by the Douglas and Grant County Public Utilities. This would improve the region's connections to the Internet and email, and would be the first leg of a future fiber network connecting the North Central and South Central Regions. The fiber networks being constructed by these counties as part of a larger scale effort (with NoaNet) are discussed in more detail in Section 3.7, Telecommunications Market Sector Review.

WSF

- **2911 Building to Olympia HQ**: Interview indicated a desire to upgrade from the existing 3 T1s to a DS3 connection, although no specific timeline for upgrade was identified.

3.2.4.2 Intelligent Transportation Systems (ITS)

Several segments of fiber were identified as probable upgrades in the immediate future. However, most of these were likely put on hold with the failure of Referendum 51. For the purposes of the Statewide Communications Plan, none of the potential upgrades was considered significant enough to warrant detailed discussion.

3.2.5 Growth

3.2.5.1 Enterprise/IT

The issues surrounding growth of Enterprise/IT network traffic are identical to those discussed under inter-regional Communications (Section 3.1.5.1). In summary, these issues include:

- General industry-wide trends toward increased bandwidth utilization;
- WSDOT's trend towards centralization of applications;
- WSDOT-specific "Big Bandwidth" applications and;
- Digitizing, storing and accessing construction drawings.

As discussed previously, it is anticipated that there will be a period of leveling off, or even a short-term decline in bandwidth utilization, due to the staff reductions triggered by the failure of Referendum 51. However, it is then anticipated that bandwidth requirements will eventually continue to grow due to the factors presented above.

3.2.5.2 ITS

The issues surrounding growth of the ITS network are similar to those discussed in the Inter-regional Communications (Section 3.1.5.2), most notably that bandwidth requirements and connectivity requirements will continue to grow as more devices are deployed in the field, and as devices are utilized differently and/or polled more frequently.

In addition to these issues, the intra-regional communications requirements include the ever-increasing desire for connection to and communications with more local municipalities, agencies, emergency service providers, etc.

The following series of tables identifies specific local municipalities and existing, planned and potential connection types by region.

WSDOT NORTHWEST REGION EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
Washington State Patrol, District 2 (Bellevue)	Video	Existing
City of Kirkland*	Data Video	Potential Potential
City of Redmond	Data Video	Planned Planned
City of Bellevue TMC*	Video Data	Existing Planned
City of Issaquah*	Video Data	Potential Planned

WSDOT NORTHWEST REGION EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
King County TMC	Video Data	Planned Planned
City of Renton TMC*	Video Data	Planned Planned
WSDOT Olympic Region TMC	Video Data	Existing Existing
City of Seattle TMC*	Video Data	Existing Planned
City of Tukwila*	Video Data	Potential Planned
SeaTac Airport*	Data	Planned
City of Kent*	Video Data	Potential Planned
City of Federal Way*	Data Video	Planned Potential
City of Auburn*	Data Video	Planned Potential
City of Maple Valley*	Data Video	Planned Potential
City of Woodinville*	Data Video	Planned Potential
City of Mercer Island*	Data Video	Planned Potential
City of SeaTac*	Data Video	Planned Potential
City of Des Moines*	Data Video	Planned Potential
Snohomish County	Data Video	Planned Planned
City of Everett*	Data Video	Planned Potential
City of Bothell*	Data Video	Planned Planned
City of Edmonds*	Data Video	Planned Planned
City of Mountlake Terrace*	Data Video	Planned Planned
City of Lynnwood*	Data Video	Planned Planned
Bellingham TMC	Data Video	Planned Planned
City of Bellingham	Data Video	Potential Potential
City of Mt. Vernon	Data Video	Potential Potential

* Source: Puget Sound Regional ITS Architecture; prepared for the Puget Sound Regional Council by IBI Group in association with PB Farradyne, Pacific Rim Resources, and the Battelle Memorial Institute; June 26, 2001.

WSDOT OLYMPIC REGION EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
WSDOT Northwest Region TMC	Data Video	Existing Existing
City of Tacoma	Data Video	Planned Planned
City of Bremerton	Data Video	Potential Potential
Tacoma Narrows Bridge	Data Video	Planned Planned
Pierce County	Data Video	Planned Planned
Camp Murray EOC	Data	Existing
Washington State Ferries	Data Video	Potential Potential
Washington State Patrol, District 1	Data Video	Existing Existing
WSDOT Southwest Region	Data Video	Potential Potential
Tacoma Fire Department	Video	Existing

WSDOT EASTERN REGION EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
WSDOT Central Washington TOC	Video Data	Potential Potential
WSDOT Olympic Region TMC	Video Data	Potential Potential
Washington State Patrol, District 4 (Spokane)	Video Data	Planned Planned
City of Spokane	Video Data	Existing Existing
Spokane County	Video Data	Existing Existing
Spokane Transit Authority	Video Data	Existing Existing
Spokane Regional Transportation Council	Video Data	Existing Existing

WSDOT CENTRAL WASHINGTON TMC EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
WSDOT North Central Region	Data Video	Existing Existing
Washington State Patrol, District 2 (Bellevue)	Data	Potential
Washington State Patrol, District 3 (Union Gap)	Data Video	Existing Existing
Washington State Patrol, District 6 (Wenatchee)	Data	Potential
City of Richland	Data	Potential
City of Kennewick	Data	Potential
City of Pasco	Data	Potential
City of Wenatchee	Data	Potential

WSDOT SOUTHWEST REGION EXISTING AND DESIRED COMMUNICATIONS LINKS		
Agency	**Communications Needs**	**Status**
ODOT Traffic Operations Management Center	Data Video	Planned Planned
Clark County TMC**	Data Video	Planned Planned
City of Vancouver TMC*	Data Video	Planned Planned
City of Camas TMC**	Data Video	Planned Planned
RTC VAST Data Warehouse**	Data	Planned
WSDOT Olympic Region TMC	Data Video	Potential Potential
WSDOT Central Washington TMC	Data Video	Potential Potential

3.3 PHONE/PBX NETWORK

WSDOT has configured and maintained a Private Branch Exchange (PBX) telephone network that allows inter-office dialing between WSDOT offices, without the use of the public switched telephone network. The primary feature of this network is the ability to use 4-digit dialing between any connected WSDOT offices in the state, eliminating any long distance charges on

** Source: Vancouver Area Smart Trek (VAST) Operational Concept, prepared by IBI Group for VAST; June 2002.

such telephone calls. Figure 17 illustrates the Network Architecture of the WSDOT PBX network.

The size and complexity of the WSDOT telephone network is comparable to that of a small telephone company. The reliability of the network is very important to the daily operation of WSDOT, and a key requirement of any contemplated enhancements or expansions is that the network remains reliable in the event of any major or minor emergencies that require attention by WSDOT staff.

3.3.1 Existing Infrastructure and Architecture

Telephone service in every WSDOT office is provided using a PBX. A PBX provides the ability to do three or four digit dialing to other phones to which it is connected. To provide access to locations outside the office, the PBX has trunk lines that can be connected to the Public Switched Telephone Network (PSTN) and to other PBXs in other offices.

The WSDOT network has been configured to interconnect a large group of PBXs as shown in Figure 14, allowing voice communication between WSDOT offices using the WSDOT network. In general, smaller PBXs are connected to main hubs at Olympia, Dayton, Yakima and Spokane. These main hubs are in turn interconnected, with Olympia being the central switch location.

The interconnection between PBXs can be carried on leased lines or over channels on a microwave system. Many of the PBXs are capable of Voice over IP (VoIP) communication, which would allow the interconnection between PBXs to occur over an Ethernet link. To date this feature has not been implemented.

The PBXs have been procured from a number of different manufacturers, and have differing capabilities, but they use standard interfaces that allow interconnection and statewide 4-digit dialing.

3.3.2 Planned Upgrades

As the number of telephone extensions in use increases over time, there comes a point (at 9999 extensions) that 4-digit dialing cannot be provided to all users. The WSDOT Network has reached this point. WSDOT has the option of introducing special dialing codes to reach each particular PBX, from where the user could dial a 4-digit extension to reach another user through that PBX, but a cleaner and more universal approach is to switch to 5-digit dialing.

This upgrade will not impact the PBX communication requirements, but it does require software upgrades to the PBXs. At this time, due to the results of Referendum 51, the previously anticipated staffing increases will likely not be experienced, and this upgrade can most likely be postponed.

3.3.3 Communications Traffic and Utilization

For voice networks running on traditional channels, the traffic analysis is based on the call volume, which is a function of the number of calls and their duration. This information can be

extracted from each PBX using the CDR (Call Detail Record), which records the origination and destination number for each call, and its duration.

The sizing of the trunks on a PBX is based on established statistical models ("Erlang Tables") that are driven by the call volume and desired level of blocking. Many PBXs will provide reporting on the call volume on the trunks. These reports can be used directly with the Erlang Tables to provide an estimate percentage of calls that were blocked due to lack of trunks. Telephone companies strive for less than 1% blocking, which means that no more than 1% of long distance calls would get a "fast busy" indication that all trunks are in use. On cellular telephone networks, blocking can be as high as 5%.

Alternately, it is possible that a review of the call volumes and CDR data could suggest that the number of trunks is greater than what is required.

3.3.4 Growth

Unlike data traffic, voice traffic on a phone network is more directly related to staffing levels and the number of connected telephones. The change in utilization is often a more steady and predictable parameter than data traffic, which can change significantly as applications and user profiles change.

One circumstance that can impact voice traffic patterns is office reorganizations, where groups that frequently communicate via telephone are moved to different offices.

In general, the increase (or decrease) in the voice communication links will be proportional to the staffing levels. It is possible that Referendum 51 will have a negative impact on the growth of voice traffic, until staffing levels eventually increase again in the future.

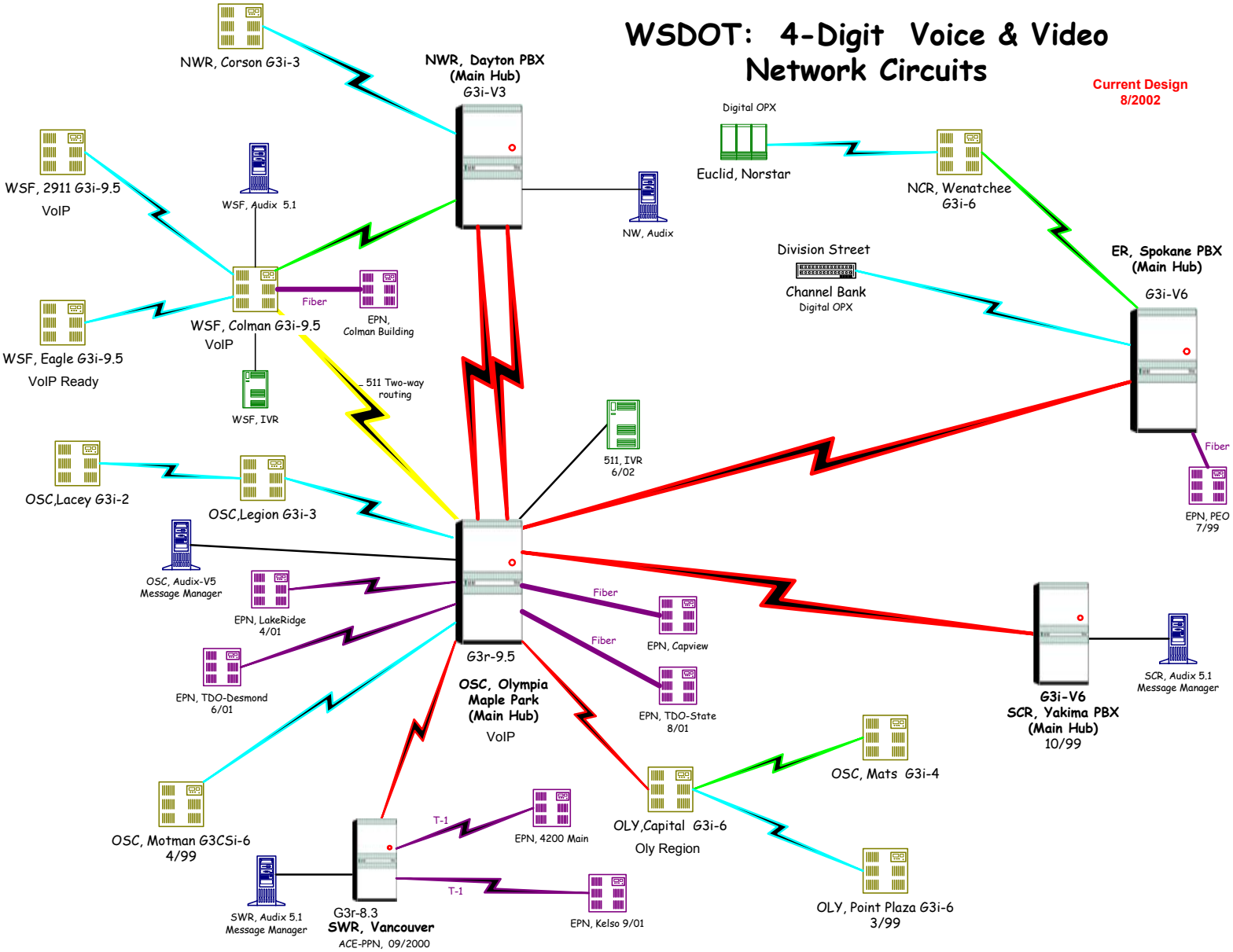


Figure 17: WSDOT PBX Network Diagram

3.4 CENTER-TO-FIELD VOICE

WSDOT's operations rely heavily on the ability to communicate with staff in the field, whether they are maintenance personnel, construction administration, Incident Response or engineers working on field design. It is also extremely important for field personnel to be able communicate with one another. To support these center-to-field and field-to-field voice communications, WSDOT employs two different technologies: cellular phones and radios. Various private communications service providers own the cellular phone networks. WSDOT employees use different providers based on the services available within the region. For the purposes of the Statewide Communications Plan, little further discussion is warranted on the usage of cellular service.

Thus, the remainder of this discussion will focus on the WSDOT voice radio network.

3.4.1 Existing Infrastructure and Architecture

The WSDOT radio network encompasses three primary components:

- **Microwave Backbone Network**: Point to point, long distance, high bandwidth (generally analog or digital DS3) connections; primarily in the 6Ghz microwave range, shared with WSP.
- **Radio Distribution Network**: Point to multipoint, medium distance, 800MHz trunked[6], networked[7], radio system for office-to-office, office-to-field and field-to-field voice communications.
- **Back-Office Connections**: Equipment and electronics that integrate the microwave and radio systems, connect to computer aided dispatch (CAD) systems, and connect to agency networks (LAN/WAN) for data communications (as applicable).

Figure 18[8] is a schematic illustrating these wireless network components. Two different facility scenarios are displayed in Figure 18:

- **Co-located Facilities**: Buildings where WSP and WSDOT are collocated. This allows for easy interconnection between the two different radio networks and the microwave network, as well as between the LAN/WAN networks of both agencies and the microwave network.
- **"Nearby Facilities"**: Buildings where the WSDOT facility is close to the site that holds the microwave and radio equipment (usually a WSP facility.) In this case, any connection

[6] Trunked: Mobiles and repeaters automatically select the best frequencies (channels) to use based on network utilization, availability and required circuit.
[7] Networked: System automatically connects with appropriate mobiles and repeaters throughout the network to facilitate communications with the intended mobile.
[8] WSP has a different radio communications network in the VHF range that is also included on this schematic and is discussed below.

between the WSDOT LAN/WAN and the microwave equipment would have to include an outside plant connection, either fiber or copper, owned or leased.

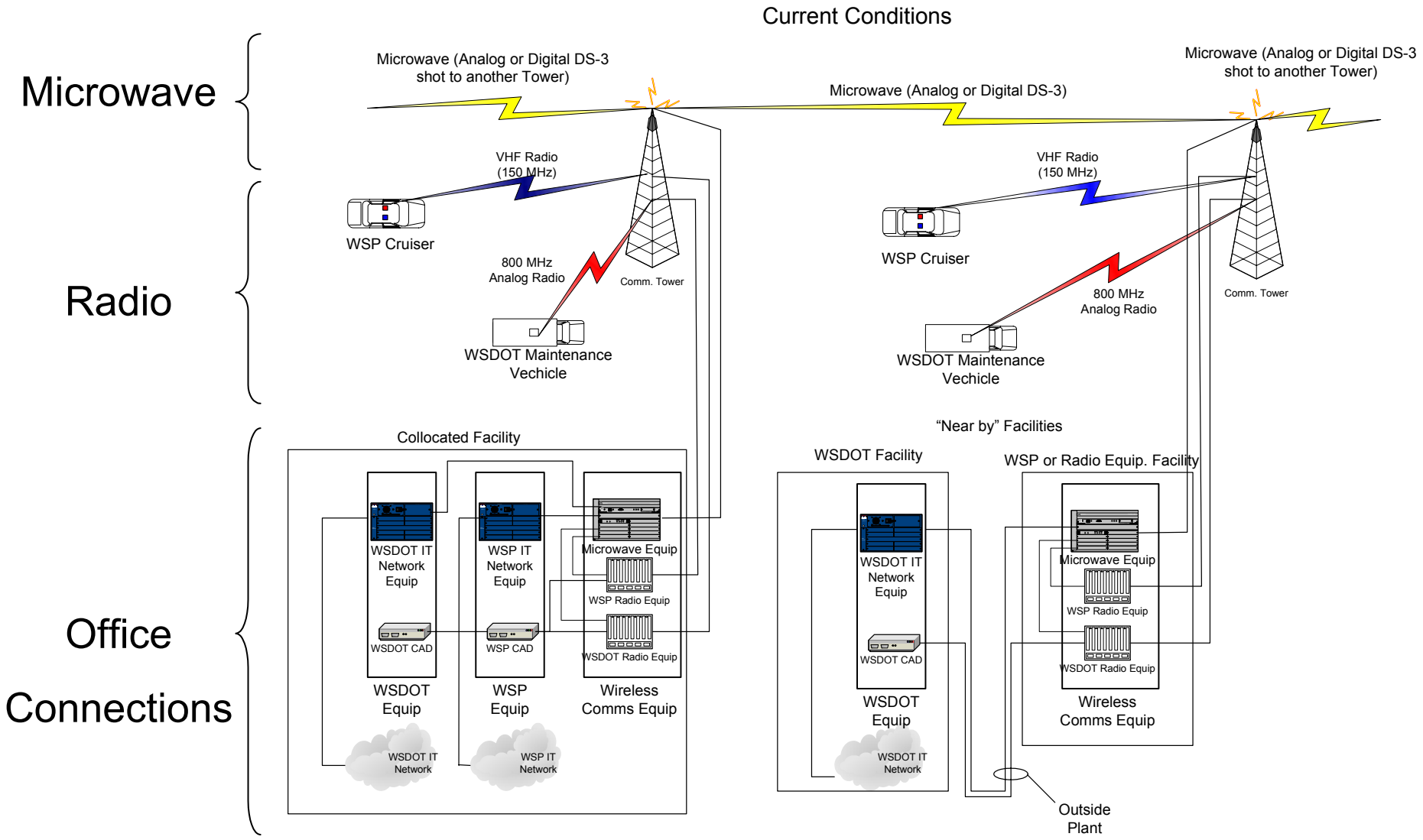


Figure 18: Components of WSDOT Wireless Network

3.4.1.1 Microwave Network

The majority of the backbone microwave network that WSDOT utilizes for radio communications was originally built—and is currently maintained —by the WSP. WSDOT has added lower bandwidth extensions to this network in order to reach sites that were not originally on the WSP network, and over time, the microwave network has increasingly been considered a key piece of "joint owned" infrastructure[9]. Figure 19 illustrates the WSP/WSDOT microwave backbone network. This map includes the following elements:

- **Facilities and Sites**: including both WSP and WSDOT microwave sites and key WSP facilities;
- **Microwave Paths**: including both WSP and WSDOT paths. As indicated on the map, some of the WSP paths are analog only, some are digital only, and some include parallel analog and digital paths. The WSDOT paths are primarily lower bandwidth, analog paths.
- **WSP Districts**: The district boundaries indicated are WSP districts (not WSDOT regions), as this map was developed by WSP.
- **Sites and paths owned by others**: There are a small handful of sites and microwave paths indicated as "owned by others", most likely the Department of Natural Resources (DNR), who also shares bandwidth on the microwave network with WSP and WSDOT.

With the signing of the Joint Operations Policy Statement (JOPS) in February of 2002 (developed and accepted by both WSDOT and WSP), the joint ownership relationship has been further formalized. A section of the JOPS document specifically addresses the wireless network. This section includes the following statement:

*"**Policy:** The WSP and the WSDOT agree to support a shared vision to create a coordinated and integrated wireless transportation communications for the safe, effective, and efficient protection of the traveling public. The agencies mutually agree it is their joint goal to implement a statewide wireless mobile communications network that is fully interoperable between agencies and workgroups to provide needed services to our field forces and support groups to benefit the citizens of this State…*

The WSP and the WSDOT agree to view their respective wireless communication systems as a single wireless system to plan for and foster interoperability among existing wireless networks and future wireless development that meets the requirements of local, state, and federal public safety."

With these goals in mind however, there are some significant challenges before the agencies to reach true interoperability. These challenges will be discussed in more detail below in Section 3.4.1.2, 800 MHz Radio Distribution.

Currently, the microwave backbone network is generally operating near capacity due to a number of reasons, including:

[9] There are actually a number of state and federal agencies that use some channels on the microwave network; however, WSP and WSDOT are the primary users.

- **Number of Users**: WSDOT and WSP each utilize approximately 1/3 of the available channels on the microwave network, both with more individual users than was originally intended. The other 1/3 of the channels are used by other state and federal agencies, including the FBI, DNR, Department of Fish and Wildlife, Parks Department, and Liquor Control Board, to name a few.

- **WSP Data**: While the network was originally built for voice radio communications, WSP does use it for data communications, primarily between Tumwater and the District offices. The data traffic between districts is generally fairly low, although it may increase when WSP completes the upgrade of its Computer Aided Dispatch system.

- **WSP Phone Network**: In addition to data communications, WSP utilizes the microwave network for their inter-office 5-digit dialing phone network.

- **Interoperability with Local Emergency Service Providers**: WSP would like to keep some channels available on the microwave network to be used for interoperability with other local agencies and emergency service providers.

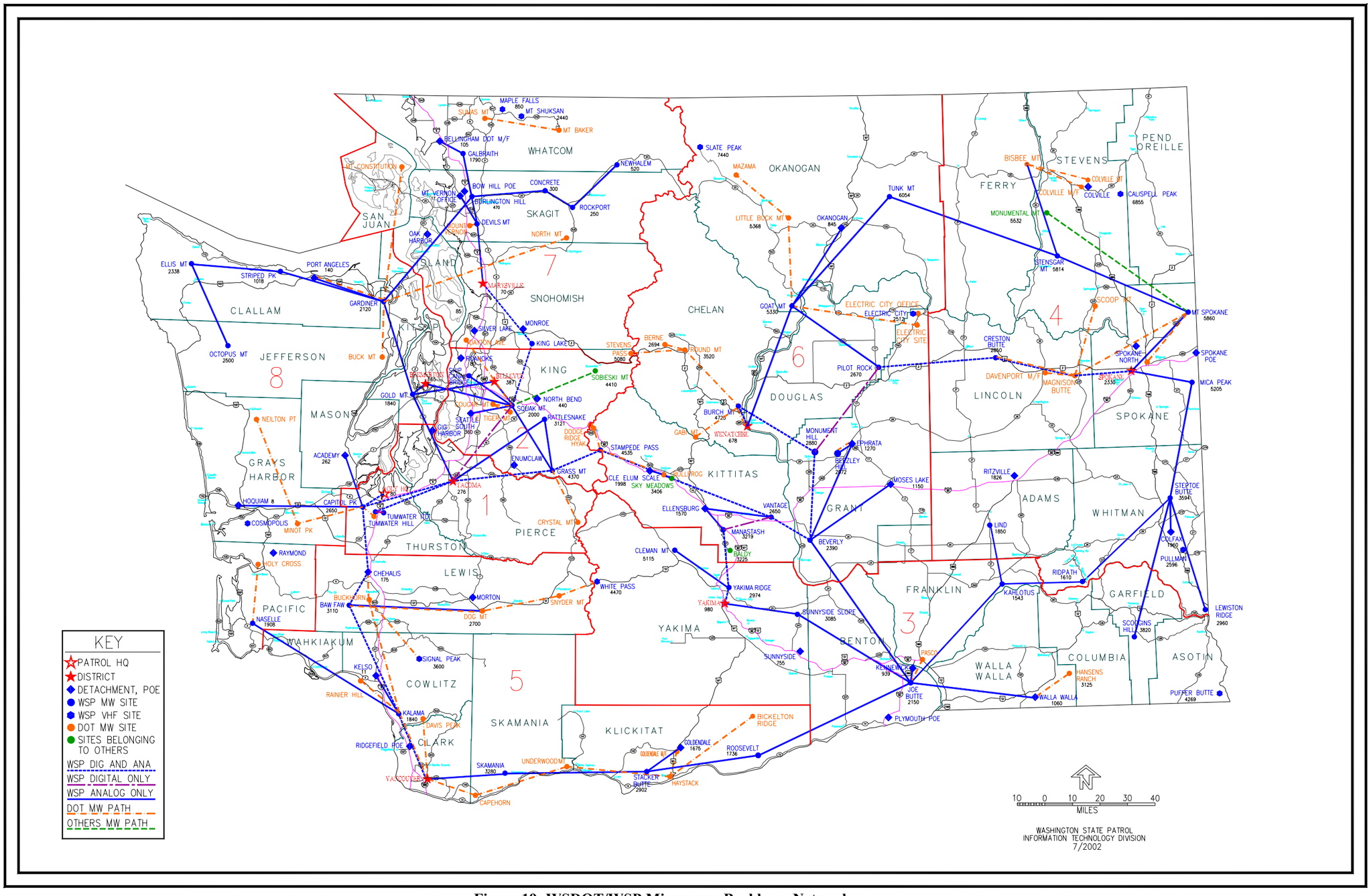


Figure 19: WSDOT/WSP Microwave Backbone Network

3.4.1.2 800 MHz Radio Distribution

WSDOT owns an extensive, statewide, 800MHz radio network. As discussed above, this is a trunked and networked analog radio system and includes repeater stations, mobile radios (installed in the WSDOT vehicles) and portables (hand held units) with over 4000 subscriber units. Because it is a networked system, mobiles, portables and dispatch stations can all communicate with one another over very large distances without the required intervention of a third party (or dispatcher). As discussed previously, the radio network uses the microwave backbone for longer distance communications.

displays the WSDOT 800MHz Radio network. This map includes four elements:

- **Existing Sites**: An existing site (usually either a facility or mountaintop tower location).
- **Proposed Sites**: There are a small handful of proposed new sites, primarily to mitigate coverage problems.
- **Poor Coverage Area**: There are a number of poor coverage pockets, primarily in rural areas and caused by geological barriers such as mountains, valleys, etc.
- **Interference**: There are a number of places with high interference, generally in urban areas along I-5 and I-90. This interference is primarily caused by NexTel; a private wireless communications provider of both cellular and radio services. NexTel's radio service operates at frequencies in close proximity to the WSDOT radio system.

There are a number of issues regarding the WSDOT 800MHz radio network that warrant further discussion, including their desire to migrate from the 800MHz band into the 700MHz band. Some of these issues are detailed below.

3.4.1.2.1 Interference

The primary factor driving WSDOT's plan to migrate from the 800MHz range to the 700MHz range is the interference problems discussed above. Interference is caused by harmful same-band digital systems, most notably NexTel. A short term, "band-aid" fix is discussed in Section 3.4.2, but only migration into the 700MHz band is considered a long-term solution.

3.4.1.2.2 Bandwidth

The 800MHz system is operating near capacity with voice traffic only. WSDOT has indicated a strong desire to investigate center-to-vehicle data communications (discussed in more detail in Section 3.5). One of the factors initiating WSDOT's desire to migrate to the 700MHz band is the additional bandwidth that would be available. This additional bandwidth is anticipated to adequately address WSDOT's center-to-field voice and data communications needs.

3.4.1.2.3 Interoperability and Project 25

Occasionally in cases of very large accidents, emergencies (fire, flood, earthquake, etc) and regional events, multiple agencies are called upon to respond and work together. Recently, there have been a number of instances across the country where responding rescue personnel from

federal, state, and local public safety agencies discovered that coordinating their efforts was extremely difficult because radios from each agency used different frequencies and signaling techniques. In many cases, on-scene commanders were forced to borrow radios from one another to coordinate their crew activities. The following excerpt[10] describes efforts that have been underway for a number of years to mitigate this problem:

"*To address the problem of interoperability as well as make better use of scarce radio frequencies, in 1989 the Association of Public Safety Communications Officials International (APCO) established Project 25 (P25). Representatives from Federal, state, and local governments began an effort to develop a set of common technical standards for land mobile radio systems…*

P25 is not a single standard but really a number of individual protocols that can be mixed and matched. A "Project 25 compliant" system may really use only a few of the many standards. For instance, a P25 system may be conventional or trunked, use encryption or transmit in the clear, and carry voice, data, or both.

P25 systems use what is called the Common Air Interface (CAI). This standard specifies the type and content of signals transmitted by compliant radios. One radio using CAI should be able to communicate with any other CAI radio, regardless of manufacturer.

At present, most public safety channels are 25 kHz wide. Current P25 radios are designed to use 12.5 kHz wide channels, allowing two conversations to take place where only one used to fit. Eventually, P25 radios will use 6.25 kHz channels, allowing four times as many conversations compared to analog.

P25 radios must also be able to operate the old way, in analog mode on 25 kHz channels. This is called backward compatibility, and allows agencies to gradually transition to digital while continuing to use older equipment."

As discussed previously, there is strong desire between WSDOT and WSP to achieve interoperable radio communications. However, there is no easy solution regarding how this interoperability should be achieved. While both agencies plan on migrating to P25 compliant systems, WSDOT intends to migrate their voice and data traffic into the 700MHz range (for reasons detailed above), while WSP plans on staying in the VHF range, to achieve interoperability with other local and federal public safety and emergency response personnel. Most likely, the WSDOT-WSP interoperability solution will eventually involve some sort of cross-band solution at either the mobile unit level or, preferably, at the repeater/base station level.

[10] Excerpt taken from "**THE CASE FOR APCO PROJECT 25 ",** by Dan Veeneman which first appeared in the June 2000 issue of Monitoring Times

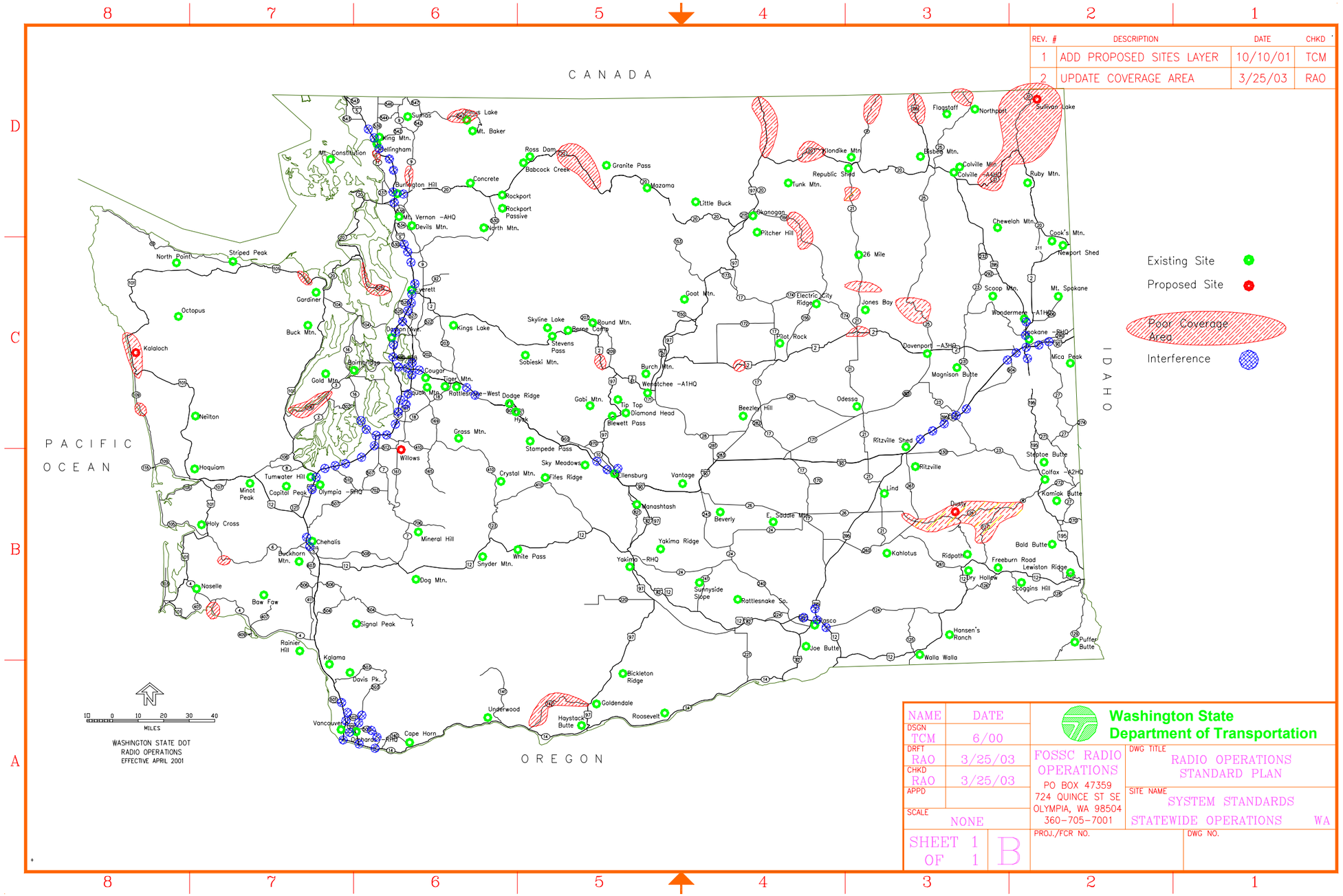


Figure 20: WSDOT Radio Network Map

3.4.2 Planned Upgrades

Figure 21 displays some of the proposed upgrades to the different elements of the WSDOT/WSP wireless network. These will be discussed in more detail in the subsequent sections on microwave and radio networks, but can be summarized as follows:

- **Microwave**: Plans are in place for certain segments of the microwave network to be upgraded to OC-3 capacity. Eventually these segments will complete three different OC-3 rings, bringing both added capacity (bandwidth) as well as increased reliability (redundancy) to the network.

- **Radio**: Both WSDOT and WSP have planned upgrades to their respective radio systems. For WSDOT, the intention is to migrate to the 700MHz band for reasons discussed above. This upgrade will also involve switching to P25 compliant digital equipment. WSP intends on staying in the VHF band, but upgrading to P25 compliant digital equipment.

- **Office Connections**: Although not specifically illustrated in Figure 21, both the radio and microwave upgrades will require upgrading the communications equipment labeled as "Office Connections" in the diagram. This is also where the "cross band" integration between WSP and WSDOT radio systems would likely occur. Finally, this is where the connection between the WSDOT WAN and the microwave network would occur, to put data on the microwave network. This will be discussed in more detail in Section 3.4.3, on Communications Traffic.

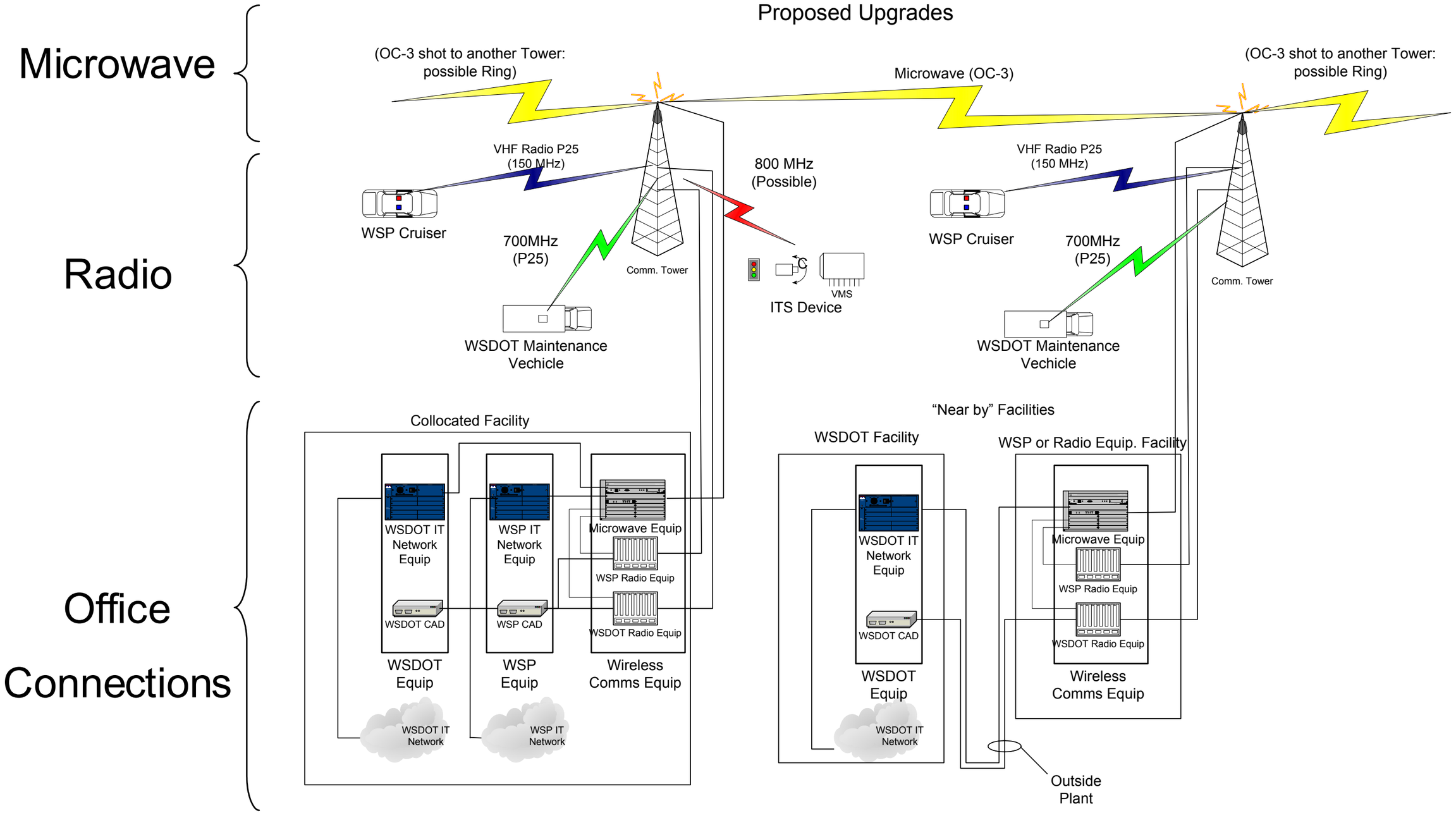


Figure 21: Proposed Upgrades to WSDOT/WSP Wireless Network

3.4.2.1 Microwave Backbone

WSDOT and WSP are currently working together to develop plans, identify funding and determine roles and responsibilities for upgrading the backbone microwave network. As discussed above, the intention is to upgrade the various DS-3 links illustrated in Figure 19 to become OC-3 links and eventually OC-3 rings. The agencies ultimately plan for three different OC-3 rings as illustrated in Figure 22. They refer to these future rings as the South Loop, North Loop and East Loop.

The purpose for the upgrade is to increase both backbone capacity (bandwidth) and reliability (redundancy.) The jump from DS-3 to OC-3 would triple the backbone bandwidth (as discussed in Section 2.4), opening up opportunities for WSDOT to utilize the backbone for uses other than voice radio communications, including data and the PBX network. Additionally, OC-3 rings are extremely reliable by nature. If a path is somehow cut or blocked, the communications traffic is automatically rerouted using the opposite side of the ring.

A decision package has already been submitted for the upgrade of the South Loop. The other two loops are slated for upgrade over the next couple of years, as funding becomes available.

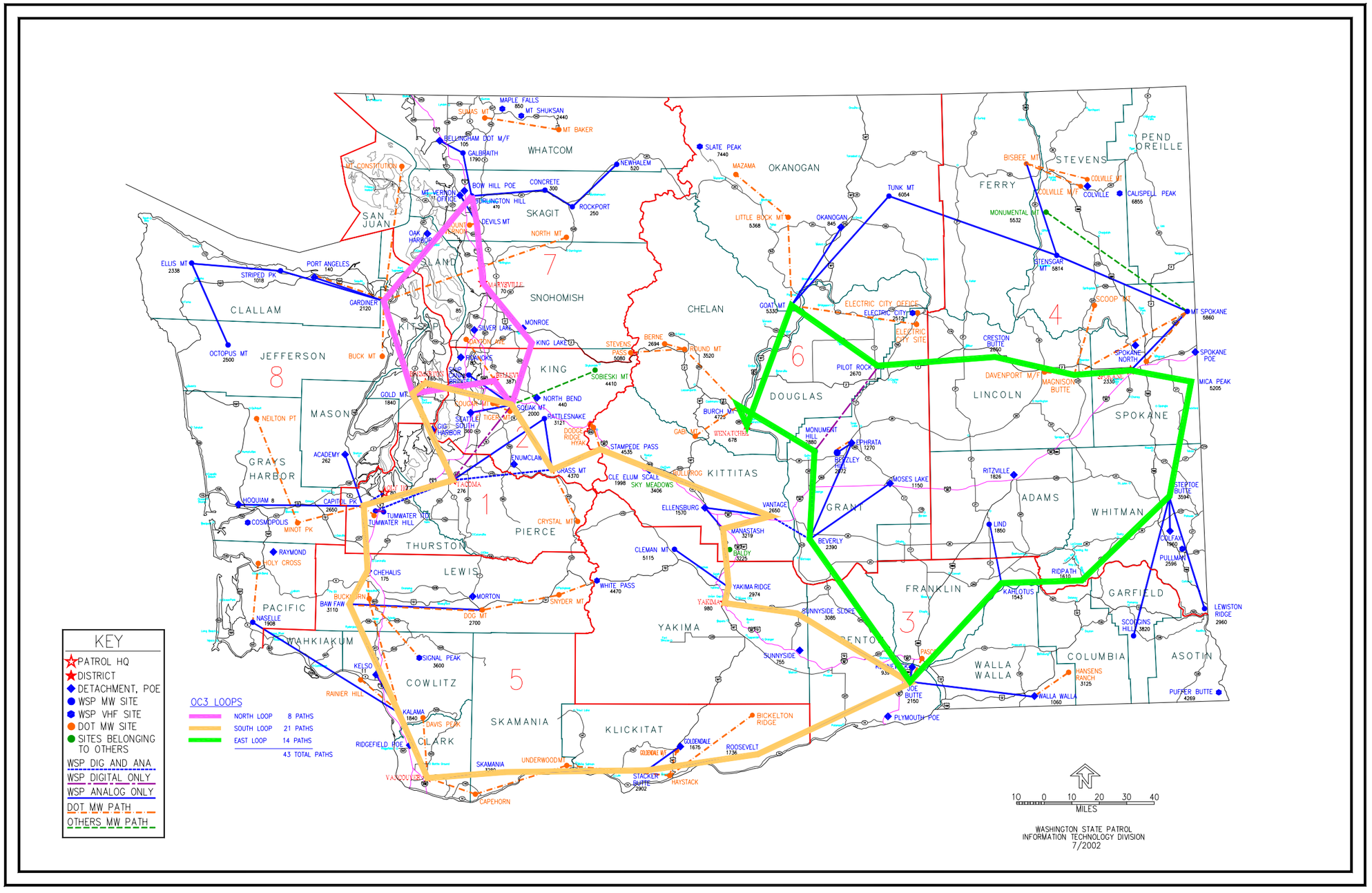


Figure 22: Proposed Upgrades to Microwave Network

3.4.2.2 Radio Network

The upgrade path for the radio network is a little less straightforward. WSP has already begun the process of their upgrade, by ordering some P25 equipment. A decision package has been submitted to upgrade to all new P25-compliant mobile units (over 900 units). WSP does not currently plan on upgrading their voice radio system to 700Mhz.

WSDOT's radio migration path is even more complex. First of all, there are a number of issues in regards to the 700MHz band, primarily its availability. While the FCC has allocated 24MHz of spectrum for public safety use in what is commonly known as the 700MHz band (actually 764-776 and 794-806 MHz), this band is, in some cases, still currently in use by UHF TV stations[11]. In addition to availability concerns with the bandwidth, the upgrade itself will be very disruptive to WSDOT operations. Equipment "change outs", both at the repeater level and at the mobile/portable level, do not happen overnight and will need to be deployed in a strategic, phased approach to ensure that WSDOT operations experience minimal interruption.

However, with those concerns in mind, WSDOT is proceeding with developing migration plans, due primarily to the interference problems discussed previously.

WSP has show interest in migrating their data communications to 700Mhz due to the bandwidth available, to support applications such as in-vehicle Internet access, email and records (including mug shots) to the vehicle.

3.4.3 Communications Traffic

Except for a handful of exceptions, WSDOT uses the wireless network primarily for voice communications to field personnel. Some of these exceptions are discussed in Section 3.5,Center-to-Field Data and Video. As far as the microwave backbone network is concerned, WSDOT is using this network exclusively for voice communications, with a sole exception: WSDOT and WSP have worked together to test a T1 data connection between Olympia and Vancouver on the microwave network. This connection has since been put into full operation and will continue to be utilized by WSDOT for data traffic.

WSP uses the microwave network for their voice, data and PBX needs.

3.4.4 Utilization

The microwave network is operating at near capacity, particularly along the I-5 and I-90 corridors. Both WSDOT and WSP indicated that the number of users on the network is much higher than was originally planned for. Additionally, WSP originally built the network to support voice communications to field personnel, and has since added both data and the PBX network to the microwave backbone.

[11] The FCC has set a date of 2006 to convert those frequencies from commercial broadcasting to public safety communications.

3.4.5 Growth

The number of voice users of the network is not anticipated to grow very much in the near future, however, the use of the network for data is expected to continue to expand.

3.5 CENTER-TO-FIELD DATA AND VIDEO

There are two main groups of communications needs under the heading of center-to-field data and video communications:

- Center-to-Vehicle
- Center-to-Field Device

These are discussed in more detail below.

3.5.1 Center-to-Vehicle

There are two programs in place currently that have center-to-vehicle data requirements: the Incident Response Team (IRT) Program and the "Snow Management" Pilot Project.

3.5.1.1 Incident Response Team

The IRT Program is viewed as a success by both WSDOT management and the general public. As described on the WSDOT website:

"*IRT staff are a specially trained group of WSDOT maintenance employees who respond to blocking incidents on our state's freeways and highways. Their main function is to clear roads and help drivers and restore the normal flow of traffic as safely and quickly as possible…*

Incident Response personnel are available 24-hours a day, seven days a week to provide traffic control, traffic rerouting, mobile communications, and assistance in incident clearance and clean up. This also includes helping motorists with a flat tire, jump starts, a gallon of gas, and many other types of motorist assistance."

Figure 23: Example WSDOT IRT Truck Exterior and Interior

The IRT project began as a pilot project covering the floating bridges during the Goodwill games in 1989, and has since grown to over 35 segments of roadway and 44 vehicles in all WSDOT regions. IRTs have a 90-minute clearance goal for all incidents.

In order to facilitate both IRT reporting and incident response, operators in most regions use laptop computers with wireless connections. There is some desire for the ability to send digital images of current conditions from the scene back to the TMC or regional HQ, particularly in the case of major incidents and emergencies. While this capability exists in some regions already, it is a cumbersome process involving downloading images from a digital camera to the laptop, attaching to an email, and sending the message. Currently, all center-to-vehicle connections with IRT vehicles are through private communications providers (CDPD and other cellular connections). Available wireless connection speeds may also hinder this effort.

3.5.1.2 Snow Management

In addition to the IRT Program, WSDOT is in Phase 2 of a "Smart Snowplow" or "Snow Management" Pilot Project. To test the feasibility and benefit of a Smart Snowplow system, WSDOT equipped several of their snowplows in North Central region with sensitive detection and data communications equipment, using the 800MHz radio network. Figure 24 illustrates an example of the Smart Snowplow concept, using a picture from the Minnesota Guidestar ITS Program.

Information collected from the snowplow includes real time vehicle location, using Differential Global Positioning System (DGPS), text-messaging capabilities between operator and dispatch, and specific sensors, including plow up/down, road and air temperature, etc. The first phase of the pilot project had mixed results. While the data collected was considered very valuable in some cases, there were problems with some of the devices sending a lot more data than was required. More importantly, it was found that the data sent over the 800MHz network had an adverse effect on voice communications, which was considered unacceptable to WSDOT. The communications equipment vendor (EF Johnson) hopes to demonstrate the proof of concept with better communications management in Phase 2.

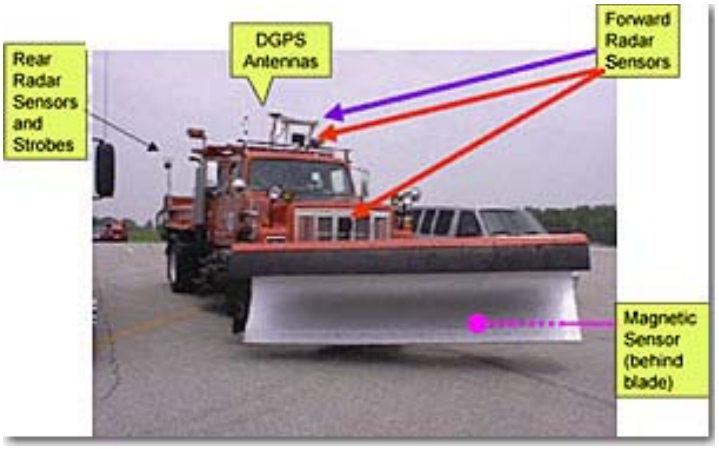


Figure 24: Example "Smart Snowplow"

3.5.1.3 Future Needs

WSDOT's IRT program is likely to continue to grow in terms of coverage, number of vehicles and data requirements. The ability to send back photos from an incident in real-time, while considered a future application, is likely to become a high-demand application once it becomes available. However, the private communications networks will not support the bandwidth that could be required, and more importantly, ATandT Wireless has already announced that they will be migrating away from CDPD services. While the service that replaces CDPD is likely to support higher bandwidth requirements, the cost may prove prohibitive across the IRT program.

WSDOT is closely tracking the success of Phase 2 of the Snow Management Pilot Project for a number of reasons. Most importantly, there is some interest in expanding the Automatic Vehicle Location (AVL) system to include more of the maintenance vehicles. Some see the ability of the dispatchers to know real-time vehicle locations as a valuable tool for more efficient maintenance of the statewide roadway network.

3.5.2 Center-to-Field Device

As discussed earlier, WSDOT's ability to communicate with field devices, most notably ITS devices such as CCTV cameras, Variable Message Signs, traffic data stations, HAR, etc, was one of the driving factors initiating the Light Lanes project. The collapse of the telecommunications market and the dissolution of the Light Lanes project was one of the key factors initiating this study.

WSDOT currently communicates with field devices in literally almost every imaginable communications medium available today, including:

- Fiber optics
- Microwave
- Licensed spread spectrum radio (including the 800MHz network)
- Unlicensed spread spectrum radio (including 802.11)
- Owned twisted pair
- Owned Coax (limited), and
- Dial-up services (T1, ISDN, DSL, 56k, etc.)

The ability of each region to make use of available resources to operate this varied network is quite remarkable. There are, however, some serious drawbacks to this diverse set of technologies. These include:

- **Maintenance**: Staff have to be trained in a number of different technologies to be able to maintain the network.

- **Standardization**: Lack of standardization leads to more difficult and costly design and often reduces quality of service.

- **Spare Parts**: Each different technology requires its own set of spare parts, which becomes costly to purchase, store and transfer to the site where needed. Alternatively, spare parts may not be held in stock by WSDOT, which leads to longer periods of down time.

- **Operational Costs**: Any dial-up services cost WSDOT monthly fees, which are often not well-documented and lead to misleading operational costs.

- **Device Utilization**: For remotely located CCTV cameras in particular, effective utilization of the device is often limited by the available bandwidth. For instance, if a slow speed dial-up connection is used to connect to a CCTV camera, snap shot, low quality images are usually all that can be collected. These images are often of less value to those utilizing them for incident or congestion verification and effectively diminish the value of the device itself.

3.5.2.1 Growth

The use and further deployment of ITS and other field devices appears likely to continue to grow for the foreseeable future. WSDOT has a number of ITS deployment projects (mostly funded) in various stages of planning, design and deployment, including the following:

Program Area	Project Title	County/Region
Safety	Critical Data Communications System Enhancement	Thurston/Olympia
	I-90 Truck/Wind Warning System Near Columbia River	Grant/North Central
Emergency Operations Projects	Remote Traffic Operations Center for Security and Emergency Applications	King/Northwest
Congestion Relief	Vancouver Area Smart Trek Operations and Communications Expansion and Traveler Information Integration	Clark/Southwest
	Tri-Cities Advanced Traffic Management System	Benton and Franklin/South Central
	Olympia Arterial Advanced Traffic Management System	Thurston/Olympia
	Seattle Incident and Operations Deployment	King/Northwest
	Lynnwood Regional ITS Operations System	Snohomish/Northwest
	Spokane Traffic Operations for Arterials	Spokane/Eastern
	Major Event Parking Advisory System	King/Northwest

Program Area	Project Title	County/Region
Traveler Information	Variable Speed Limit System on Stevens Pass, US-2	Chelan/North Central
	US-395 Columbia River Bridge Traffic Operations and Traveler Information System	Benton/South Central
	Central Washington Traveler Information Variable Message Sign (VMS)	Adams and Grant/North Central and Eastern
	I-82 Yakima Area Traveler Information System	Yakima/South Central
	I-5 Through Nisqually Valley – Ice Warning System	Thurston and Pierce/Olympia and NW
	SR14 Traveler Information Enhancements	Skamania/Southwest

Appendix B includes brief project descriptions of each of these projects, from the list of 2002 Proposed Washington State ITS Projects. As can be seen, every region has plans for additional field devices and associated communications requirements. While most are low speed connections (virtually all non-video applications only require low speed and low bandwidth communications) they still all require some sort of connection.

3.6 POLICY ISSUES

Some issues that have direct impact on WSDOT's communications needs, network, infrastructure and implementation options, are best defined as policy issues. Some examples include:

- **JOPS Discussion on Wireless Network**: As discussed above (Section 3.4), there is language in the Joint Operations Policy Statement referring specifically to the joint-owned wireless network, agreeing to "create a coordinated and integrated wireless transportation communications [network]." While both parties have accepted this language, the key will be to translate this agreement into specific actions, committees and deployable projects.

- **Wireless Task Force**: There is an existing inter-agency wireless task force that was created primarily to identify solutions for the interference problems discussed in detail in Section 3.4. This wireless task force is an advisory committee only, with no real authority and a very limited scope.

- **Limited Wireless Design Standardization/Review**: While there are a number of wireless communications projects connecting centers to field devices, they are generally designed in an ad-hoc manner, with no agency-wide design standards, and no centralized review process. There is some concern that as these projects continue to be deployed, they may cause interference problems with other systems and/or may not be deployed with the "bigger picture" in mind.

3.7 TELECOMMUNICATIONS MARKET REVIEW

The last section of "Findings" relates to a brief analysis of the telecommunications market in the State of Washington. Specifically, the goal of this task was to try to identify any opportunities to obtain fiber optic plant that a communications provider is willing to sell (or lease long term) along key sections of WSDOT infrastructure. The driving factor of performing this task was the logic that perhaps the collapse of the telecommunications market had opened up an opportunity to purchase existing fiber and/or conduit at low cost. This fiber could then potentially be used for either center-to-center or center-to-field applications, depending on route, location, etc.

3.7.1 Long-Haul Providers in Washington

Appendix B provides a high-level map of Long Haul telecommunications providers in the Northwest. This map was available on KMI Corporation's website at www.kmicorp.com [12]. KMI maintains and sells a number of state, national, and international fiber optic route maps. They have updated maps of the State of Washington for sale.

Figure 25 provides a matrix of long-haul telecommunications providers in the State of Washington, indicating which ones appear to own infrastructure along key WSDOT corridors. All the providers own infrastructure along I-5, either border-to-border (Oregon to British Columbia) or from Seattle-to-Portland.

[12] This map is to be used for informational purposes only. KMI does not verify 100% accuracy of this information.

Company	I-5 Corridor	Note	Seattle-Spokane	Seattle-Wenatchee	Seattle-Yakima	Other
360networks	**Yes**	**Border to Border, probably railroad**	no	no	no	
Enron	**Yes**	Seattle to Portland	no	no	no	
GST Telcom	**Yes**	Seattle to Portland	no	no	no	
Broadwind (IXC)	**Yes**	Seattle to Portland	**Yes**	no	no	
Qwest	**Yes**	Seattle to Portland (probably redundant route)	no	no	no	
PFNet	**Yes**	Seattle to Portland	no	no	no	
Frontier	**Yes**	Seattle to Portland (possible redundant route)	**Yes**	no	no	
MCI/Worldcom	**Yes**	**Border to Border, probably railroad**	**Yes (through Everett)**	**Yes (through Everett)**	no	**Everett-to-Wenatchee & Everett-to-Spokane (seems to bypass Spokane likely Hwy 2 both) & Wenatchee-to-Tri-Cities**
Touch America	**Yes**	**Border to Border, probably railroad**	**Yes (prob. Hwy 2)**	**Yes (prob. Hwy 2)**	no	
AT&T	**Yes**	**Border to Border, including specific Olympia to Tacoma Run**	**Yes (with redundancy)**	**Yes (prob. Hwy 2)**	**Yes**	**Redundant routes to Spokane, one appears as I-90 the other Hwy2**
Electric Lightwave	**Yes**	Seattle to Portland (probably redundant route)	**Yes**	no	no	**Portland-to-Yakima-to-Spokene**
Sprint	**Yes**	**Border to Border**	**Yes**	**Yes (prob. Hwy 2)**	no	
Williams	**Yes**	Seattle to Portland	no	no	**Yes**	**Portland-to-Yakima (loop to Seattle)**
Level3	**Yes**	**Border to Border**	no	no	**Yes**	
BPA/NoaNet	**Yes**	**Border to Border**	**Yes**	**Yes**	**Yes**	**Fiber to Tri-Cities & Olympic Penninsula, including Olympia-to-Port Angeles & Olympia-to-Aberdeen**

Figure 25: Long Haul Communications Providers in Washington

This matrix provide useful information in a couple of different scenarios:

1. If a communications provider DOES own infrastructure along a specific route (e.g., Highway 2) that WSDOT it interested in, WSDOT may contact them directly to investigate lease/buy options.

2. If a communications provider DOES NOT own infrastructure along a specific route (e.g., Highway 2) that WSDOT it interested in, WSDOT may contact them directly to see if they are interested in cost-sharing the construction or some other shared resource-type effort.

Figure 26 below provides a list of contacts for some of these communications providers.

Company	Contact Name	Ph. #
Electric Lightwave	Jennifer Bush	206-812-2296
360networks	Dick Wong	604-648-7818 office 604-307-6862 cell
NoaNet	Tom Villani	509-662-1244 office 509-668-0409
AT&T	Rick Leclair	425-943-3477
MCI/Worldcom	Mike Patterson	916-576-6721
Touch America	Commercial Customer C	(800) 590-1025
Sprint/Verizon	Ken Ng	(206) 254-5034
Enron	Company HQ	(713) 853-6161
Williams Comm (WiTel)		1.877.367.0767 (fiber) (866) 945-8351
Level3		(877) 253-8353

Figure 26: List of Telecommunications Provider Contacts

3.7.2 Fiber Optic Lease Options (360networks)

Many of the communications providers identified in Figure 25 were contacted as part of this task. The first question asked of each contact was whether the provider would consider either selling or entering into a long-term lease agreement with WSDOT for dark fiber or conduit along these key routes. At the time that this report was drafted, none of the providers would consider selling fiber or conduit and only 360networks indicated any interest in long-term lease options.

360networks owns a fiber backbone around the United States and Canada. This backbone runs parallel to the I-5 corridor from border-to-border, however, 360 has less available fiber in the segment from Everett north to the Canadian border than they do from Everett south to the Oregon

border. Appendix C[13] provides a route map of 360networks fiber route from border-to-border along the I-5 corridor.

Since 360networks had indicated interest in discussing a long-term lease agreement with WSDOT, they were asked to provide a budgetary estimate of what such a lease would entail. Appendix D provides a copy of the letter issued by 360networks in response to this request. To summarize the letter, 360 offered the following budgetary estimates:

1) Vancouver, WA to Seattle
Term: 20 Year IRU[14]
Fiber IRU Non-recurring Charge: $277,100 (2 fibers)
Route Maintenance Yearly Recurring Charge: $57,050 ($350 per route mile)

2) Seattle to Vancouver, BC
Term: 20 Year IRU
Fiber IRU Non-recurring Charge: $738,000 (2 fibers)
Route Maintenance Yearly Recurring Charge: $71,750 ($350 per route mile)

Other Services:
Splicing Non-recurring Charge: $5,000 per splice
Collocation: $750 per rack (Monthly Recurring Charge), $1,000 per Rack Installation Fee
Power: $15 per amp (Monthly Recurring Charge)

3.7.3 Long-Haul Circuit Charges

Another part of this task included requesting "circuit pricing" estimates from the telecommunications service providers for some of the key WSDOT Center-to-Center connections. Communications providers are often wary of presenting circuit-pricing information, unless they are in serious negotiations with a prospective client. Therefore, at the time that this report was drafted, only MCI/WorldCom had provided circuit-pricing information. This circuit-pricing information has been included as Appendix G, and is to be used for informational purposes only. This may help give budgetary estimates for approximate ongoing leased line charges for various circuit sizes.

Subsequent to the completion of this task, WSDOT continued negotiations with Qwest and NoaNet for several upgraded circuits (as discussed in Section 3.1.4). Because of WSDOT's bulk purchasing capabilities, the current state of the telecommunications industry, and WSDOT's successful negotiations, the monthly service fees negotiated with Qwest and NoaNet are substantially less than those estimates offered by MCI/WorldCom for even higher bandwidth. While the exact service fees are confidential, an estimate of $1500 per termination for dedicated bandwidth of 100Mbs has been verified as a close approximation.

[13] 360network noted the following "*this is not an engineering drawing, and as such the fiber route information may not be accurate or current. Please use it only as a high level reference.*"
[14] Indefeasible Right of Use

3.7.4 Monthly Lease vs. IRU

Comparing monthly lease cost to the long-term lease (IRU) costs (using 360networks as an example) are by no means, an "apples to apples" comparison. There are a number of issues that need to be taken into consideration, such as the Level of Service agreements that the communications providers are willing to provide, ownership and maintenance of network equipment, actual bandwidth available, annual increases in monthly rates, etc. However, a high-level look at cost comparison is worthy of some analysis.

Using the newly negotiated rates with Qwest and NoaNet in comparison with the 360networks dark fiber IRU (and including last mile construction costs to tie into 360networks fiber), there does not appear to be incentive to further analyze an IRU agreement at this time.

Example IRU vs. NoaNet Lease (all values approximate)

Vancouver to Seattle 20-year IRU through 360networks		
Fiber IRU non-recurring cost:		**$277,000**
Route maintenance cost:	$57,050 / year * 20 years	**$1,141,000**
Last Mile Cost:	$35/ft * 5 miles	**$925,000**
Equipment cost:		**$300,000**
	Total 20 year:	***$2,643,000***

Vancouver to Olympia 100Mbs NoaNet Estimate		
Initial install cost:		$**1500**
Monthly Fee:	$1,500 * 12 mo * 20 year	**$360,000**
Last Mile Cost:		**$0**
Equipment cost:		**$0**
	Total 20 year:	***$361,500***

3.7.5 NoaNet

Of all of the private telecommunications providers in the State of Washington, NoaNet (Northwest Open Access Network) is the most unique provider, and possibly the "best fit" for WSDOT's needs. As described on their website:

"*Northwest Open Access Network (NoaNet) is a nonprofit corporation that has licensed fiber optic cables from the Bonneville Power Administration (BPA) and other sources to create a carrier-class Data and TDM network for the Utilities and rural communities in the Pacific Northwest…*

The members of NoaNet are nonprofit, community-owned electric and water utilities. They use the NoaNet fiber optic system for utility purposes such as real-time metering, energy management, load control and networking among remote utility facilities. NoaNet provides excess capacity to others on a cost-based, nondiscriminatory basis. Communities are using the NoaNet system to interconnect schools, hospitals, judicial systems, libraries, and emergency services. The availability of fiber optics enables economically depressed communities to attract new businesses. NoaNet is also the rural community's on-ramp to the Internet, offering access through Tier 1 providers…

NoaNet's SONET-based, passive DWDM network was originally designed in 1999 and 2000 and is meant to carry advanced telecommunications and data services throughout rural Washington State. Our network parallels the BPA transmission system and uses fiber supplied by BPA, and other providers in areas where BPA doesn't have fiber."

The reasons that NoaNet may be extremely attractive to WSDOT are two-fold:

- **Pricing:** NoaNet's affiliation as a non-profit organization allow them to offer extremely competitive long-haul circuit pricing,

- **Location:** NoaNet's network creates a large ring around the State of Washington with many point-of-presence facilities located very close to WSDOT key sites.

Appendix E displays NoaNet's network map around the State of Washington, including fiber routes and point of presence facilities. Figure 27 is NoaNet's list of Point-of-Presence facilities in the State of Washington, including the physical address as well as Latitude and Longitude of each site.

NOANET POP LIST								
Site Name	Prop. Ownership	State	City	Zip Code	County	CLLI	NPA	NXX
Aberdeen	Collocation at Grays Harbor facility	Washington	Aberdeen	98520	Grays Harbor	ABE	360	532
Ashe	BPA	Washington	Richland	99352	Benton	ASH	509	942
Bell	BPA	Washington	Mead	98042	Spokane	BEL	509	242
Big Eddy	BPA	Oregon	The Dalles	97058	Wasco	BDY	541	320
Chehalis	BPA	Washington	Chehalis	98532	Lewis	CHS	360	740
Chief Joseph	BPA	Washington	Bridgeport	98813	Douglas	CHJ	509	686
Cle Ellum	Private	Washington	Cle Elum	98922	Kittitas	CLE	509	674
Columbia	BPA	Washington	Rock Island	98850	Douglas	COL	509	662
Covington	BPA	Washington	Kent	98042	King	COV	253	372
Creston	Private	Washington	North Creston	99122	Lincoln	CTN	509	636
Ellensburg	Private	Washington	Ellensburg	98926	Kittitas	EBG	509	933
Franklin	BPA	Washington	Pasco	99301	Franklin	FKN	509	542
Grand Coulee	BOR	Washington	Grand Coulee	99133	Grant	GRC	509	632
Happy Valley	BPA	Washington	Sequim	98382	Clallum	HVY	360	582
John Day	BPA	Oregon	Rufus	97050	Wasco	JND	541	739
Lexington	BPA	Washington	Longview	98632	Cowlitz	LEX	360	414
McNary	BPA	Oregon	Umatilla	97882	Umatilla	MCY	541	922
Midway	BPA	Washington			Benton	MID	509	
Moxee	BPA	Washington	Yakima	98901	Yakima	MOX	509	225
Olympia	BPA	Washington	Olympia	98502	Thurston	OLY	360	236
Pittock	Collocation	Oregon	Portland	97205	Multnomah	PIT	503	215
Ross	BPA	Washington	Vancouver	98663	Clark	ROS	360	546
Satsop	Collocation at Grays Harbor facility	Washington	Elma	98541	Grays Harbor	SAT	360	532
Sharkey	Private	Washington	Coulee City	99115	Douglas	SHK	509	632

Figure 27: NoaNet Point of Presence List for Washington

4. REQUIREMENTS

This section presents the requirements for the WSDOT communication networks. These requirements have been developed based on investigation into the current configurations and discussions with a range of WSDOT personnel throughout the state. The requirements will then form the basis for recommendations for modifications and upgrades to the WSDOT communication networks.

4.1 GENERAL REQUIREMENTS

The following general requirements for the WSDOT Statewide Communications Network are based on "best practices" of the communications industry. General requirements are the guiding principles that apply to many areas of the WSDOT communication network.

4.1.1 Needs Based

The provision of communication systems must be based on the needs of the organization. It must be recognized that these needs will change over time, and that for some years, the requirements for some forms of communications (data and center- to-vehicle in particular) have continually increased.

4.1.2 Enterprise Wide

The scope and need for a statewide communication network is driven by communication requirements in the following key areas. These requirements must be addressed for each WSDOT office:

- **Voice:** Communication within WSDOT and to provide access to outside lines.
- **Enterprise IT:** – The need to interconnect the IT networks between WSDOT offices to allow sharing of data and software applications, and provide email and Internet access to all employees.
- **ITS:** The ability to share traffic and incident related information between the groups responsible for ITS systems.
- **Center to Vehicle Communication:** A number of communication systems have been deployed that use communications between a control center and a vehicle on the road. These types of applications are expected to increase in the near future and will encompass additional capabilities and scope.
- **Homeland Security:** In the event of a natural disaster, or other major incident, the network must support the needs of the homeland security forces.

4.1.3 Reliable

A key parameter for any communication is its reliability. The WSDOT network must reliably support the needs of the organization, as many staff are dependant on voice or data communication in order to carry on their daily work.

Reliability is critical where the network is used for public safety applications. For example, the sections of the network that are shared with WSP can carry communications traffic that is critical to the safety of the officers in the field. Similarly, a number of the WSDOT communication applications improve the safety of motorists.

The WSDOT network will experience a change in communications traffic loading and usage in the event of emergencies or when it is used for homeland security purposes. Reliability is critical at these times, when some of the communication links may not be fully operational. Prioritization of communication links is also a consideration as some forms of communication are more important than others.

4.1.4 Flexible

The needs of the state will always be changing according to the organizational structure, funding challenges, and the scope of services provided to the public. The applications that are supported by the network will change over time, often with significant changes in bandwidth requirements. For these reasons, the communication network must strive to maximize flexibility.

4.1.5 Spare Capacity

In order to accommodate the anticipated (and historically trended) growth in the overall communications traffic carried by the network, spare capacity is required. This includes spare capacity in the overall capacity of provisioned channels, as well as spare capacity in buildings, cabinets and equipment chassis.

4.1.6 Standards: Equipment

As the size and configuration of the network changes over time, and in accordance with the changes in technology, there is a requirement for standards that will be used statewide. These standards include equipment types, communication protocols, and procedures.

WSDOT needs to select components that are interoperable between vendors to avoid "sole source" situations, and to maintain competitive pricing. Selection of equipment that is provided by a number of vendors also tends to ensure that the technologies are those that will continue to be supported by the industry.

4.1.7 Standards: Communications Protocols

The WSDOT network must support a number of standard communication protocols. These include:

- TCP/IP for Enterprise Networks
- T1 for PBX links
- DS-3 for high capacity links
- EIA/TIA 232 for ITS applications

- NTCIP for ITS applications (where these standards have been accepted)
- P25
- Some legacy systems use other protocols, but these protocols can be converted to one of the above transmission protocols where required.

4.1.8 Maintainable

WSDOT has a small technical maintenance team with a wide coverage area. With the emphasis on reliability, it is important that the technicians can quickly and effectively maintain equipment. The use of standard equipment, as described above, reduces network complexity and the number of components that must be understood to administer and maintain such a network. It also reduces the number of equipment types for which spares have to be maintained.

With the pressure of staff restrictions, it is necessary to minimize the personnel required for maintenance and troubleshooting.

4.1.9 Cost Effective

The network design must not only be cost effective, but it must recognize the challenges related to the number of WSDOT sources from which communication projects are funded. There are also considerations related to the funding of networks that are shared between agencies, particularly the microwave network shared between WSDOT and WSP.

4.2 INTER-REGIONAL COMMUNICATIONS

4.2.1 Data Communication

There is a current need to upgrade the capacity of some of the inter-regional links to support the data network requirements. Several of the links between Olympia and the Regional Headquarters are operating at capacity at this time. The bandwidth needed on all inter-regional links is expected to increase over time.

4.2.2 Redundancy

It is desirable to increase the reliability of these inter-regional links by providing redundant communication paths. Redundancy can be achieved by utilizing different routing or different technologies.

4.2.3 Cost Implications

The inter-regional links are the longest links, and often have the highest overall bandwidth requirements. These links are therefore the most expensive links, and provide the greatest opportunity for cost savings.

4.2.4 Center- to-Center Links

Interviews with the ITS personnel identified a need for center-to-center communication between most of the ITS control centers, located in each of the regions. These links typically carry video transmission, so they can be high in total bandwidth requirements. The anticipated ITS center-to-center communication needs are identified below.

In addition to existing ITS centers, the proposed STOC/EOC will require additional connections (and the associated communication channels) to the regional TMCs in addition to what has been identified above.

4.3 INTRA-REGIONAL COMMUNICATIONS

4.3.1 Data Communication

Based on data from October 2002, there are 12 intra-regional links in the data communication network that require increased capacity. The primary intra-regional communications need is to increase the capacity of these links, and to support growing bandwidth requirements on other existing links.

4.3.2 Redundancy

As with regional TMC links to Olympia, key intra-regional communication links require upgrade to redundant links. Particular candidates are the links between regional TMCs and the regional maintenance area offices.

4.3.3 Center to Center Links

There is the potential to use the WSDOT communication network to provide Center-to-Center communication between local or municipal TMCs and the regional TMCs operated by WSDOT. Currently, this type of communication is only used in Northwest Region, but it is likely to be required in the future for other local TMCs.

4.4 PHONE/PBX NETWORK

4.4.1 Capacity

The basic need for the voice network is to maintain operation of the communication network that supports inter-office dialing. There is an identified need to implement 5-digit dialing, as the 4-digit dialing capability has been expanded, but this is primarily a PBX configuration issue rather than a communication requirement. More extensive use of SCAN services will marginally increase the requirements for communication between PBXs.

4.4.2 Resiliency

Although the exact requirements for homeland security have not been determined, it is expected that there will be a requirement to provide resilient communications to a central location, likely in

the Olympia area. Such resilient communications would be fault tolerant to equipment failures and disruptions in some communication media. It would also anticipate the loading on voice communication systems that often occur during emergency situations.

4.5 CENTER-TO-FIELD VOICE

WSDOT will need to take measures to minimize the interference between the 800MHz radio network and same-band private telecommunications providers. This will likely involve short-term upgrades to boost signal strength, but ultimately require migration to the 700MHz band. Bandwidth requirements are likely to level off in the near-term, but will begin to grow again in the future as discussed in section 3.4.

4.6 CENTER-TO-FIELD DATA AND VIDEO

The success and likely expansion of the IRT program and the migration of the telecommunications service providers away from CDPD service, will likely drive WSDOT to consider alternate center-to-vehicle data communications. Depending on implementation schedule, this may coincide with migration of the radio voice network to the 700MHz band. Alternately, new private communications service may be required.

The Smart Snowplow Pilot Project will be closely watched and its benefits measured to determine whether similar implementations are desired more extensively through the maintenance fleet. If it proves beneficial, this may have significant impact on center to vehicle data requirements, with the same issues as discussed above.

ITS devices will continue to be deployed throughout the state, as discussed in Section 3.5. Communications to these devices may require dial-up, dedicated leased line or fiber optic connections, depending on bandwidth requirements and density of devices. Opportunities may exist to utilize the radio network to communicate with these devices, particularly with very low data devices and in remote areas, where voice traffic is minimal. Alternately, if WSDOT migrates to the 700MHz band, additional bandwidth may be available for data communications to devices. The following section discusses expansion of the fiber network in more detail, particularly identifying likely corridors for expansion.

4.7 POLICY ISSUES

In order to support other recommendations, some specific policy changes may be required. Some examples include the following:

- Better coordination between WSDOT and WSP for changes in policy, review of infrastructure and joint decision making build/buy/lease opportunities.
- Statewide consistency in review of wireless construction projects
- Better documentation of infrastructure and asset management
- Better coordination with maintenance personnel when designing and developing new applications or connections

5. ANALYSIS

The following section includes a series of maps generated from the GIS Communications Infrastructure database, which was developed specifically for this project. Each map has been generated individually to analyze specific issues such as high utilization segments in a region and to look for other opportunities, such as utilizing existing fiber optic routes or microwave paths to augment or replace leased line connections. Each analysis map is discussed in detail below.

It is important to note that the data for this GIS database has come from numerous sources. Therefore the level of accuracy is for planning purposes only and some discrepancies may be noted, particularly between sites, microwave shots and fiber locations.

5.1 INTER-REGIONAL COMMUNICATIONS

Figure 28 is the first of two Inter-regional Analysis maps. The figure is focused on high utilization segments, as discussed in Section 3.1 (and summarized in Figure 6). As illustrated in Figure 28, only the Olympia to Wenatchee HQ T1 connection is currently operating over 20% utilization. However, the Olympia to Yakima HQ, Olympia to Spokane HQ, and Olympia to Tumwater HQ connections are all currently operating near the 20% threshold.

Figure 28 also displays some possible microwave routes that may be utilized to either augment (and bring redundancy) or replace (to minimize operational cost) the leased line connections between the Olympia HQ and each of the regional HQ offices. As this figure illustrates, several microwave segments (or "shots") would have to be upgraded to complete the connection between Olympia and each regional HQ.

Further analysis should be completed to compare the estimated cost of upgrading each of these microwave paths, as compared to on-going leased line connections.

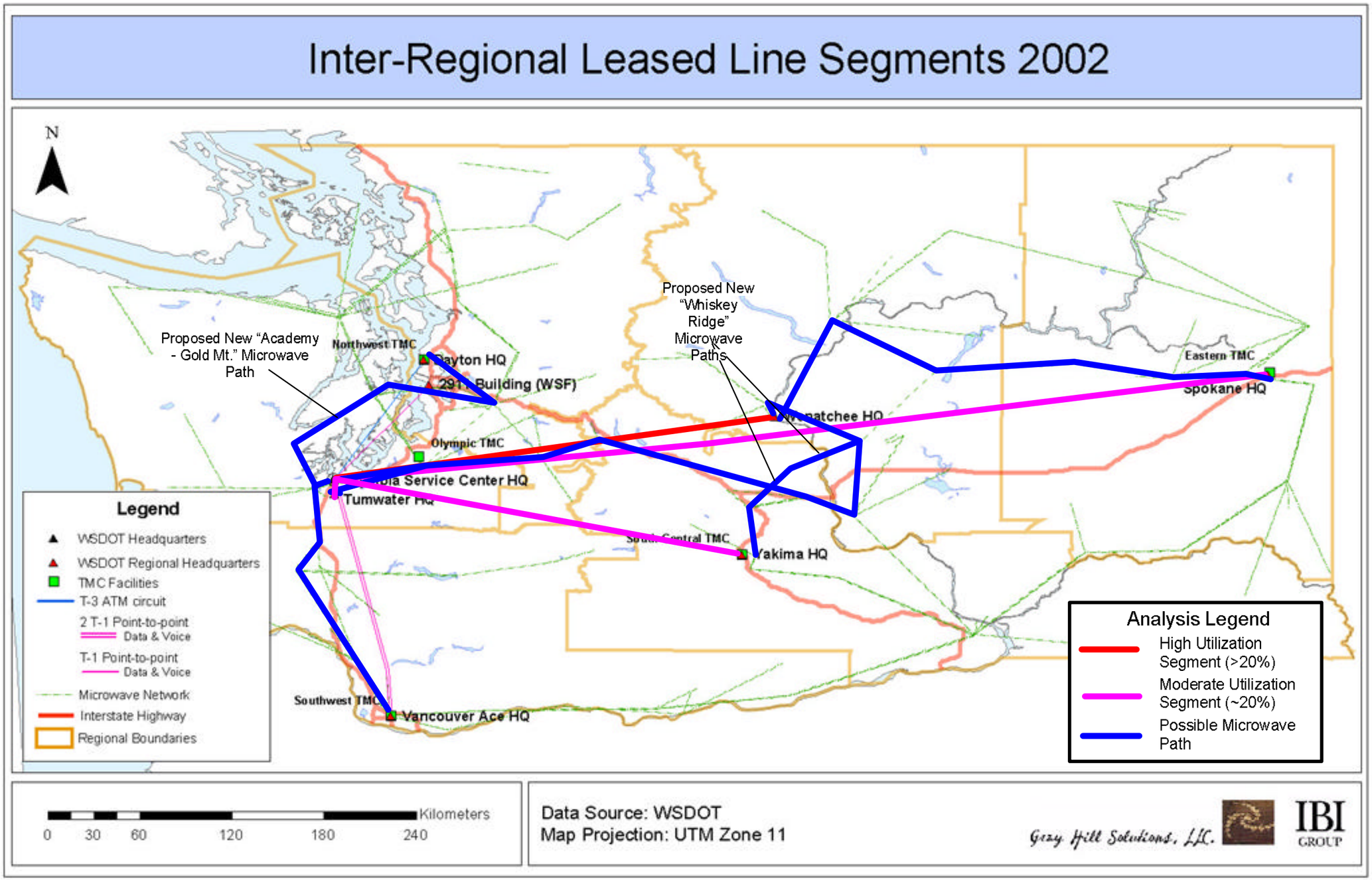


Figure 28: Inter-regional Analysis - Bandwidth Utilization

Figure 29 is the second of the Inter-regional Analysis maps. This figure is focused on Inter-regional ITS Communications Requirements. This schematic reflects the discussion from Section 3.1.2.2 on ITS Center-to-Center (C2C), and puts this discussion into a geographic context. As discussed previously, several of the regions had indicated interest in being able to share video and data, or in some cases data only[15], with a neighboring region. This requirement will become more prevalent as more field devices are deployed, particularly along regional boundaries. The specific C2C requirements illustrated in this figure include the following:

- Vancouver TMC to Olympic TMC: Video and Data
- Olympic TMC to Dayton (NW) TMC: Video and Data
- Dayton TMC to Bellingham TMC: Video and Data
- Wenatchee HQ to South Central TMC: Video and Data
- Eastern TMC to South Central TMC: Data Only
- South Central TMC to Dayton TMC: Data Only

The requirements should be confirmed before detailing planning for these inter-regional Center-to-center connection is begun. However, the analysis illustrates that point-to-point connections between the WSDOT regional TMC do not currently exist. Instead, several segments of the network are utilized (and all routed through Olympia) to send data or video between two neighboring TMCs.

Also illustrated in Figure 29 are the possible microwave routes that may be utilized to support these ITS C2C requirements. Since many of the TMCs are collocated with the regional HQs, several of these microwave paths are identical to the paths identified in Figure 28. When this is the case, it might be said that an upgrade of the microwave path is required to support both ITS and Enterprise/IT requirements.

A few of the microwave paths identified in both Figure 28 and Figure 29 do not currently exist in the WSP/WSDOT network. These paths have, however, been identified as future microwave shots by WSP/WSDOT in their documentation of the network, and have been labeled on the figures.

[15] "Data only" may include access to and/or control of VMS, HAR, RWIS and other field devices. Video accessed from the WSDOT website is considered sufficient for these connections.

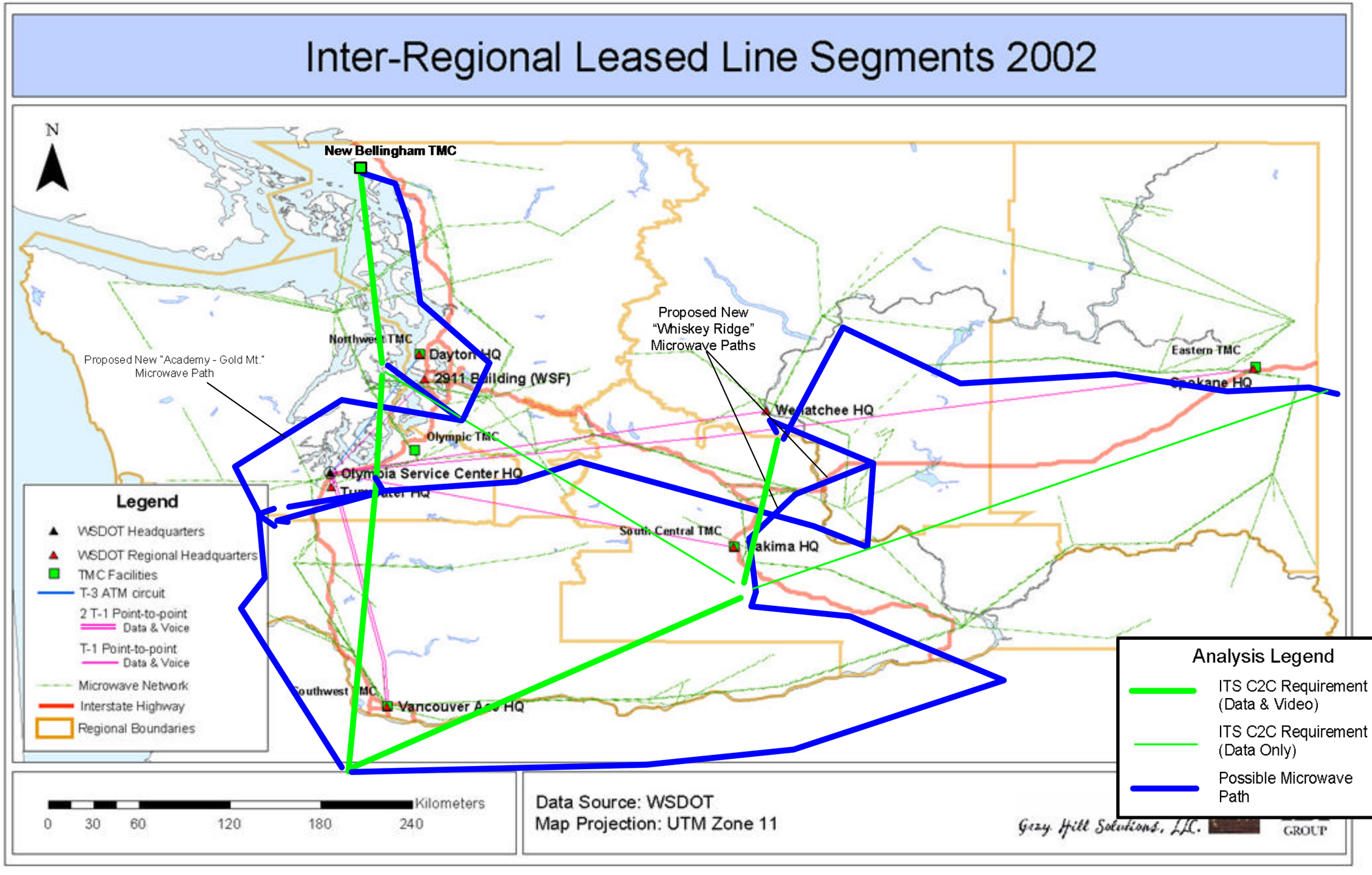


Figure 29: Inter-regional Analysis - ITS Center-to-Center (C2C) Requirements

5.2 INTRA-REGIONAL COMMUNICATIONS

This section includes a series of analysis maps focused on each individual WSDOT region. The high utilization segments are identified, as discussed in Section 3.2 and summarized in

Figure 16. In addition to the leased line connections, alternate communications options are highlighted in each of the maps including possible microwave and/or fiber routes.

As discussed in Section 3.2, many of these regional sites share Frame Relay T1s (referred to as frame relay clusters in this document.) Often times, one or more of the sites in the Frame Relay "cluster" are much larger than the other sites or at least have higher bandwidth requirements, due to the nature of the facility. If one of the sites in the "cluster" is such a high bandwidth user that it causes a network slowdown, the other sites will experience the slowdown as well. The purpose of identifying the individual high bandwidth segment is to indicate which leased line segments would bring the biggest benefit if upgraded or replaced by either microwave or fiber connections.

Figure 30 illustrates the leased line connections in the Northwest Region, highlighting the high bandwidth connections, possible microwave routes and fiber optic routes. As indicated in this map, there are three Frame Relay clusters that are considered high bandwidth users (i.e., exceed 20% utilization). Also indicated in the map are the individual segments within each cluster, which are the highest bandwidth users. (Note that the routing of the frame relay clusters was estimated in all of these maps, based on an assumption of the location of the telco hub that connects the members of the cluster.) The map indicates that only two of the high utilization sites (Bellingham and Mt. Vernon) appear to be directly on the microwave routes. In other words, none of the other sites could even take advantage of microwave as a communications medium, unless new microwave paths were specifically constructed.

There are, however, several sites that are either directly on or very near the existing fiber optic ring that WSDOT owns and maintains. In fact, three of the sites (Survey, Roanoke and Mercer) are already utilizing the fiber backbone for communications back to Dayton. As discussed in Section 3.2.4, WSDOT IT is currently working together with the Advanced Technologies (ITS group) to identify opportunities to migrate the Everett Satellite site (known internally as El Capitan) to a fiber connection. The intention would then be to change the frame relay cluster currently connecting Everett North to Mt. Vernon, Burlington, Stanwood and Bow Hill, and instead have this cluster be connected to El Capitan. With the fiber backbone from El Capitan to Dayton in place, this would free up bandwidth for all sites that are currently sharing this cluster.

Other opportunities may include working with the cities of Seattle, Bellevue and Redmond to utilize their fiber optic networks to connect to the various sites located within each city. These cities may be able to provide "last mile" connectivity between WSDOT's fiber network and the various sites. This could be particularly beneficial in Seattle, where WSDOT has over 10 different facilities.

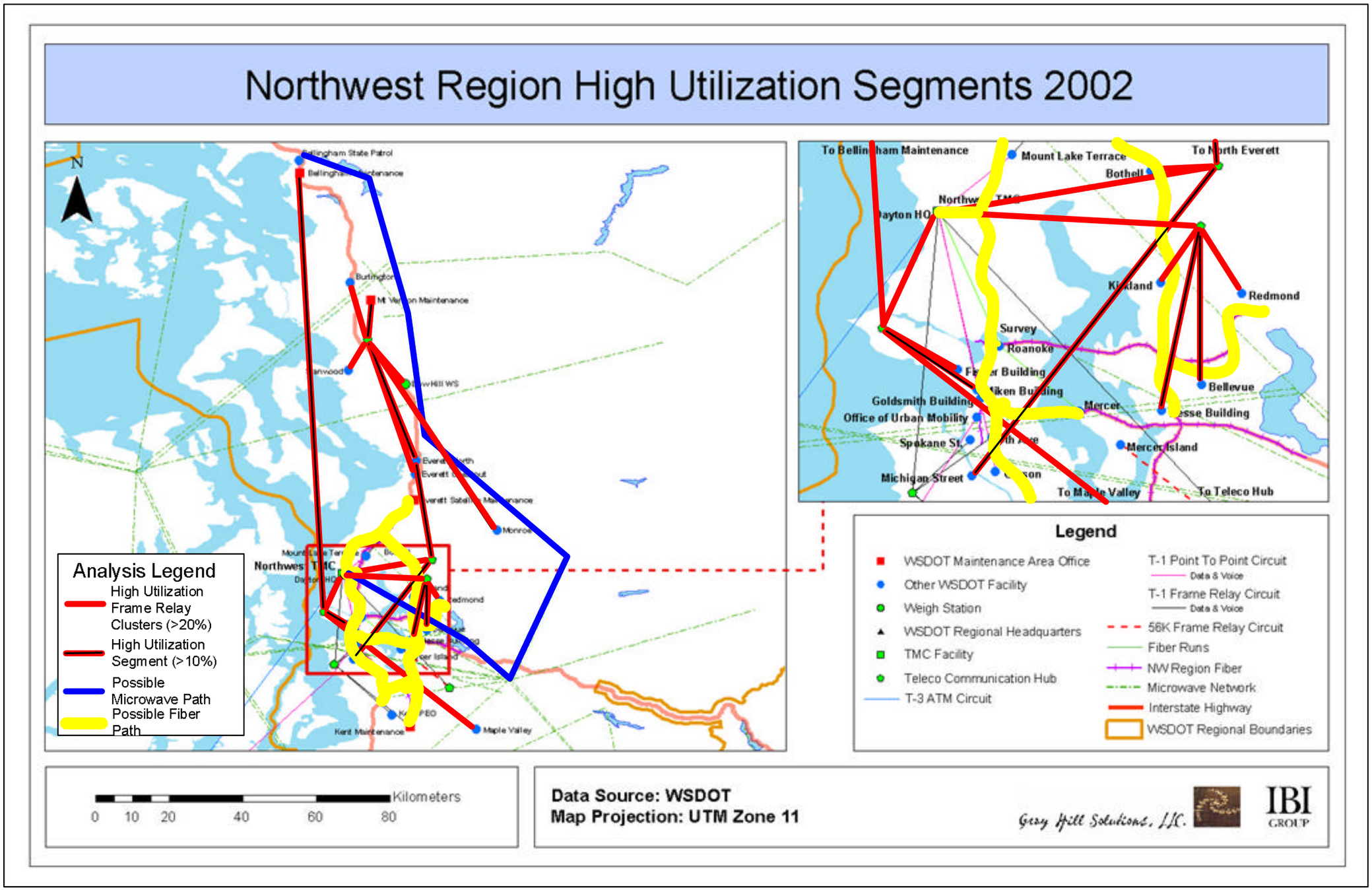


Figure 30: Northwest Region Analysis Map

Figure 31 illustrates the Olympic Region's leased line segments, high bandwidth Frame Relay clusters and microwave paths. As indicated in this map, two of the Frame Relay clusters are currently high bandwidth utilization groups. In this case, two of the highest bandwidth sites (Port Angeles Maintenance and Port Orchard—one in each cluster) appear to be directly on microwave paths. Other, smaller sites (particularly Aberdeen Maintenance and Elma) also appear to be able to be fed via microwave. However little benefit would be gained as compared to the cost of upgrade.

Figure 32 illustrates the Southwest Region's leased line segments, possible microwave paths and fiber optic plant. In this region, none of the leased line segments or Frame Relay clusters is currently operating at over 20% utilization; therefore none are indicated as high bandwidth utilization segments. However, this is partly because Kelso and Vancouver Maintenance (two of the larger sites) are currently using two dedicated T1 connections, triggering even higher on-going operational costs. As indicated in the map, the Kelso site may be able to utilize microwave to connect back to the Vancouver HQ. The Vancouver maintenance site however, is not on an existing microwave path. The map indicates that the Vancouver Maintenance site may be located near the future fiber planned for construction along I-205. WSDOT should consider designing this new fiber to connect Vancouver Maintenance back to the regional HQ.

Figure 33 illustrates the South Central Region's leased line segments and possible microwave paths. In this region, none of the leased line segments or Frame Relay clusters is currently operating at over 20% utilization. Possible microwave paths are indicated on the map to show potential connectivity between the Yakima HQ and the field offices, and there appear to be opportunities to use microwave to contact the majority of the offices in the region. However, since none of the segments are running near capacity, the benefit of upgrading the microwave network in this region may be lower than the others.

Figure 34 illustrates the Eastern Region leased line segments, high bandwidth utilization frame relay cluster and possible microwave paths. In Eastern Region, there is one high bandwidth utilization cluster and in this cluster, the connection between Eastern Region HQ and the 1st Avenue site is the most constrained segment. The other high bandwidth connection is between Eastern Region HQ and the Wandermere Maintenance Facility, but since this cluster is just under 20% utilization, it is not indicated on the map as a high utilization cluster.

While some of the remote facilities may be able to be fed by microwave (specifically Colville, Colfax and Davenport Maintenance facilities), it is unclear whether the Wandermere or the 1st Avenue site could be fed by microwave. While both appear to be directly along existing microwave paths, neither are at a terminus of the microwave shot. More work would have to be preformed to determine whether these sites are candidates for microwave connectivity back to Eastern Region HQ.

Figure 35 illustrates the North Central Region leased line segment, high utilization segment and possible microwave paths. In this region, the only high utilization segment is the Wenatchee – Euclid segment, which does not appear to be a candidate for a microwave shot. All other potential microwave paths to other facilities shown on this map are likely low priority as they are lower bandwidth connections. The microwave path between Wenatchee and Yakima was discussed previously.

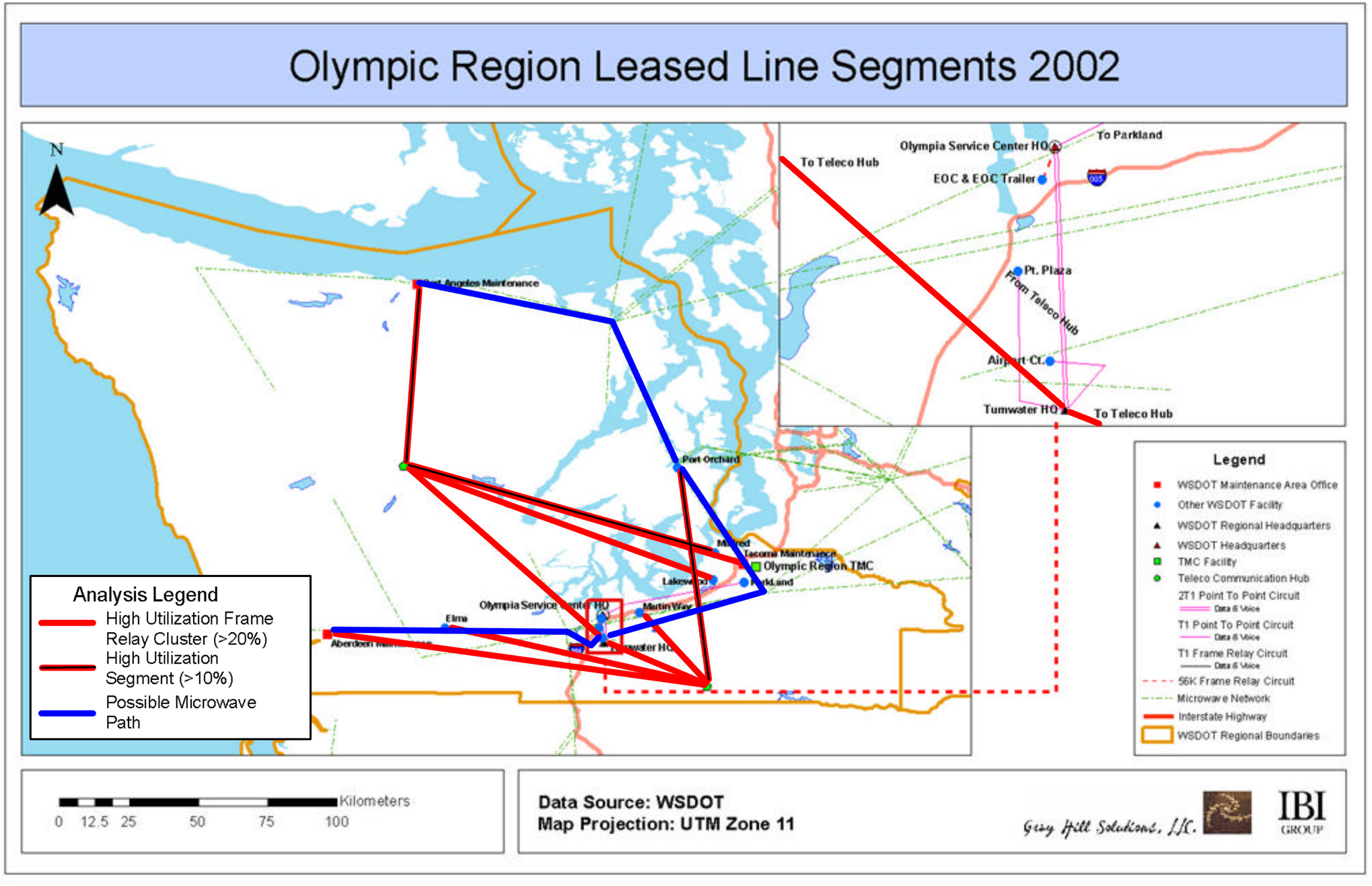


Figure 31: Olympic Region Analysis Map

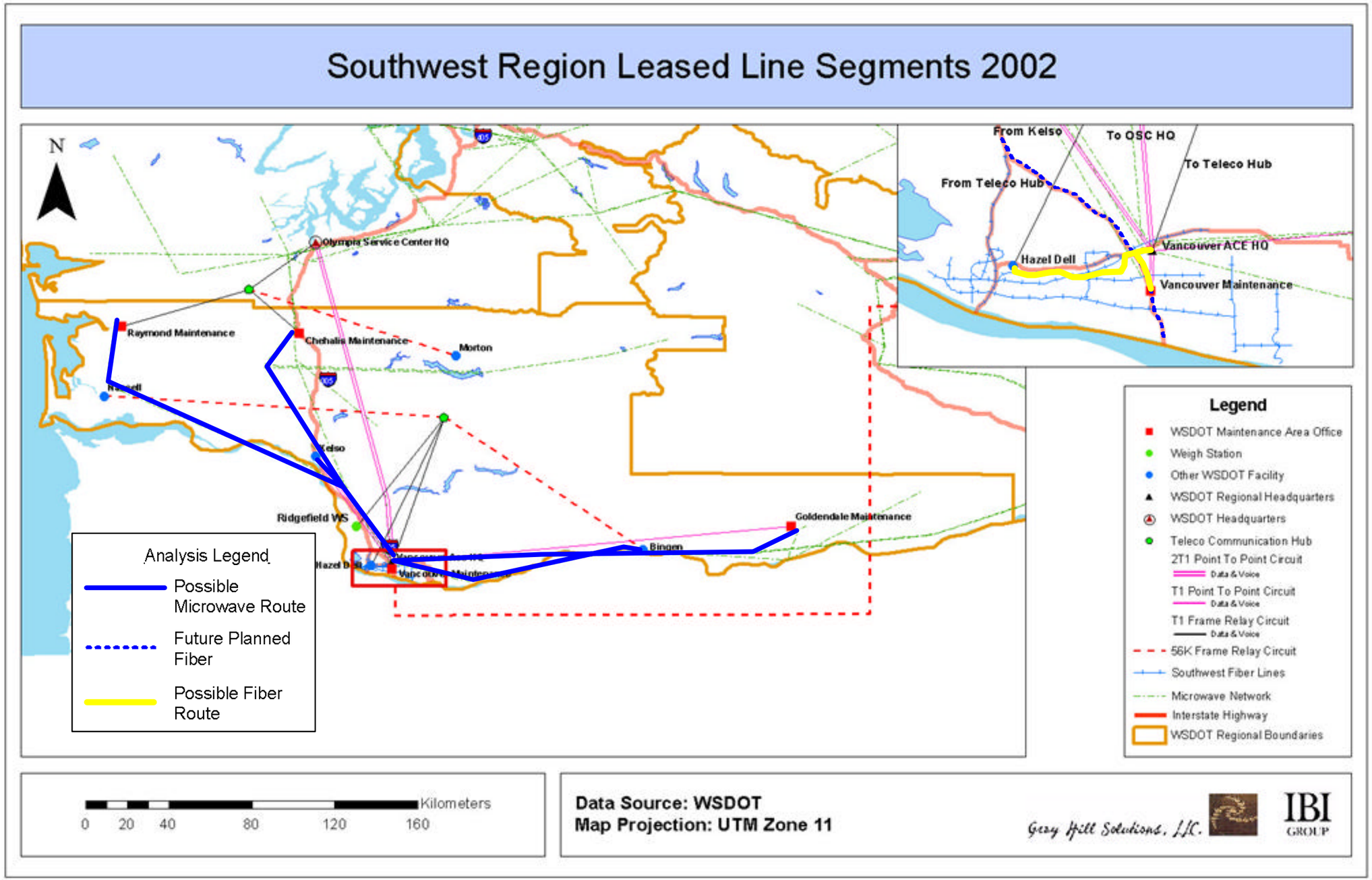


Figure 32: Southwest Region Analysis Map

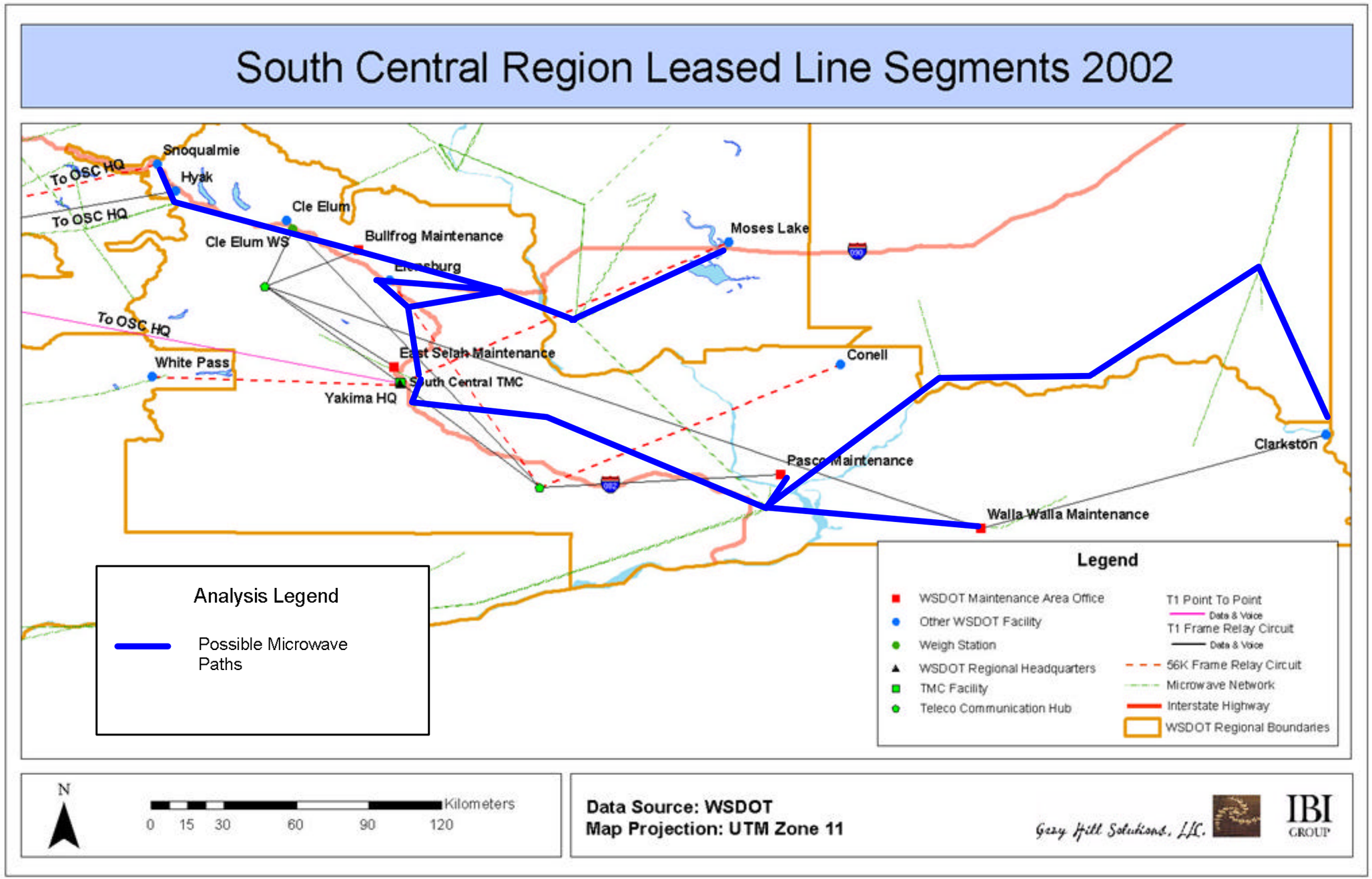


Figure 33: South Central Region Analysis Map

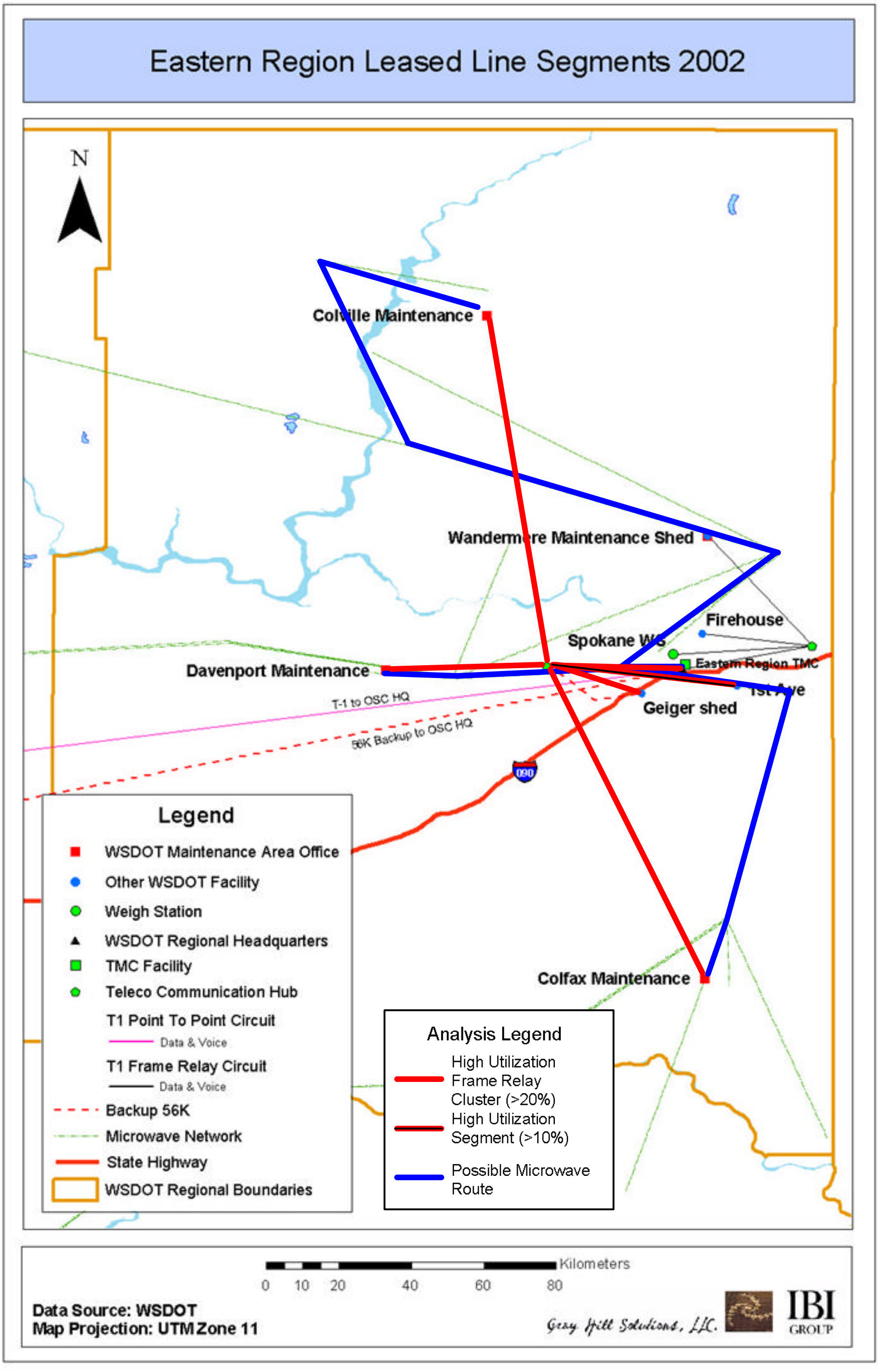


Figure 34: Eastern Region Analysis Map

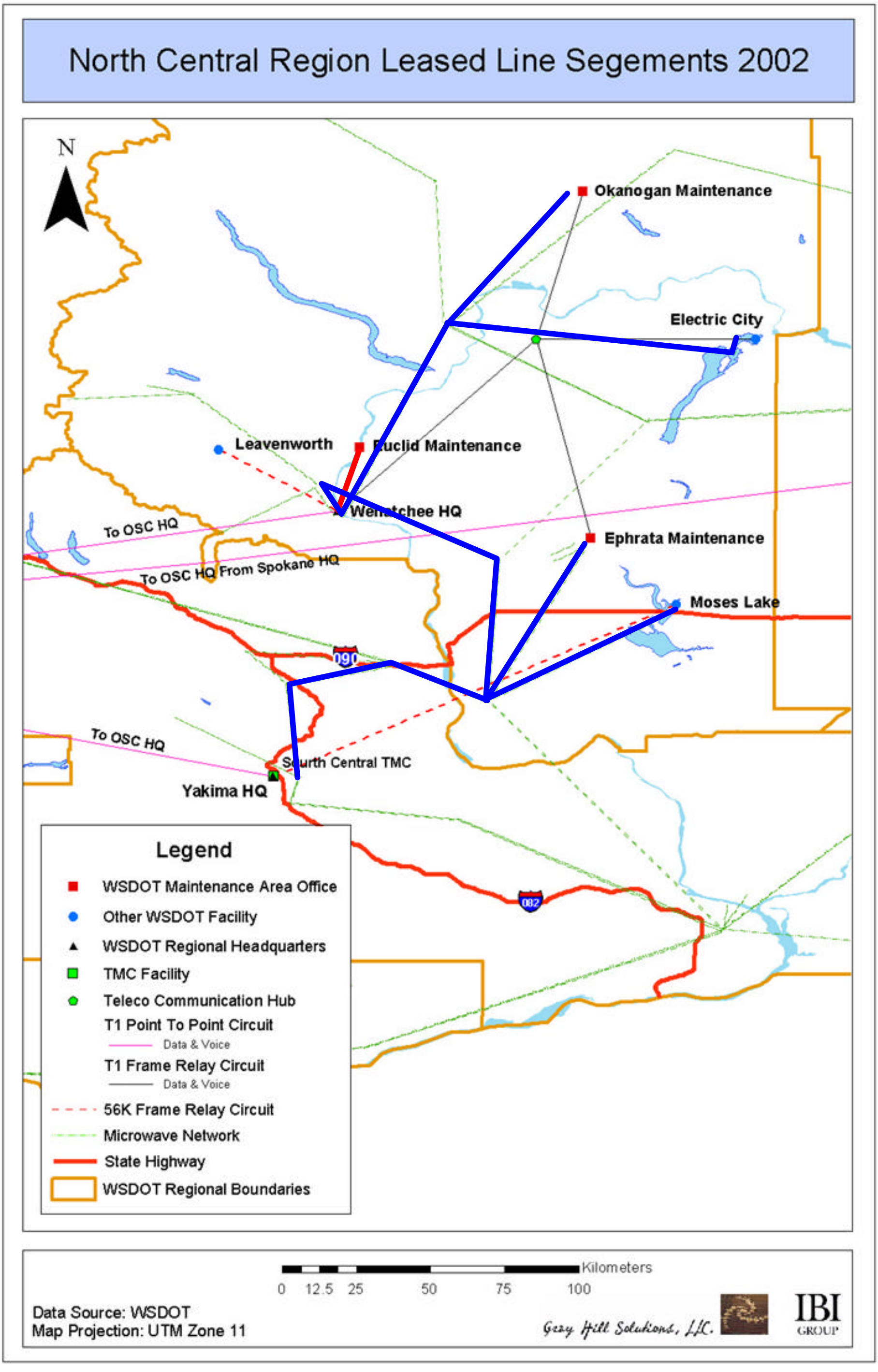


Figure 35: North Central Region Analysis Map

Figure 36 illustrates the Seattle – Everett Metro Area Analysis map. This map was specifically developed due to the density of sites in the Seattle metro area, especially when all of the WSF sites are included (WSF sites were not included in NW Region map.) The high utilization Frame Relay clusters identified in Figure 30 for the NW Region are not repeated in this map. Only the WSF high utilization cluster is included here.

As displayed on the map there appear to be no specific opportunities to utilize either microwave or fiber to connect to any of the WSF sites in the metro area, including the high utilization cluster.

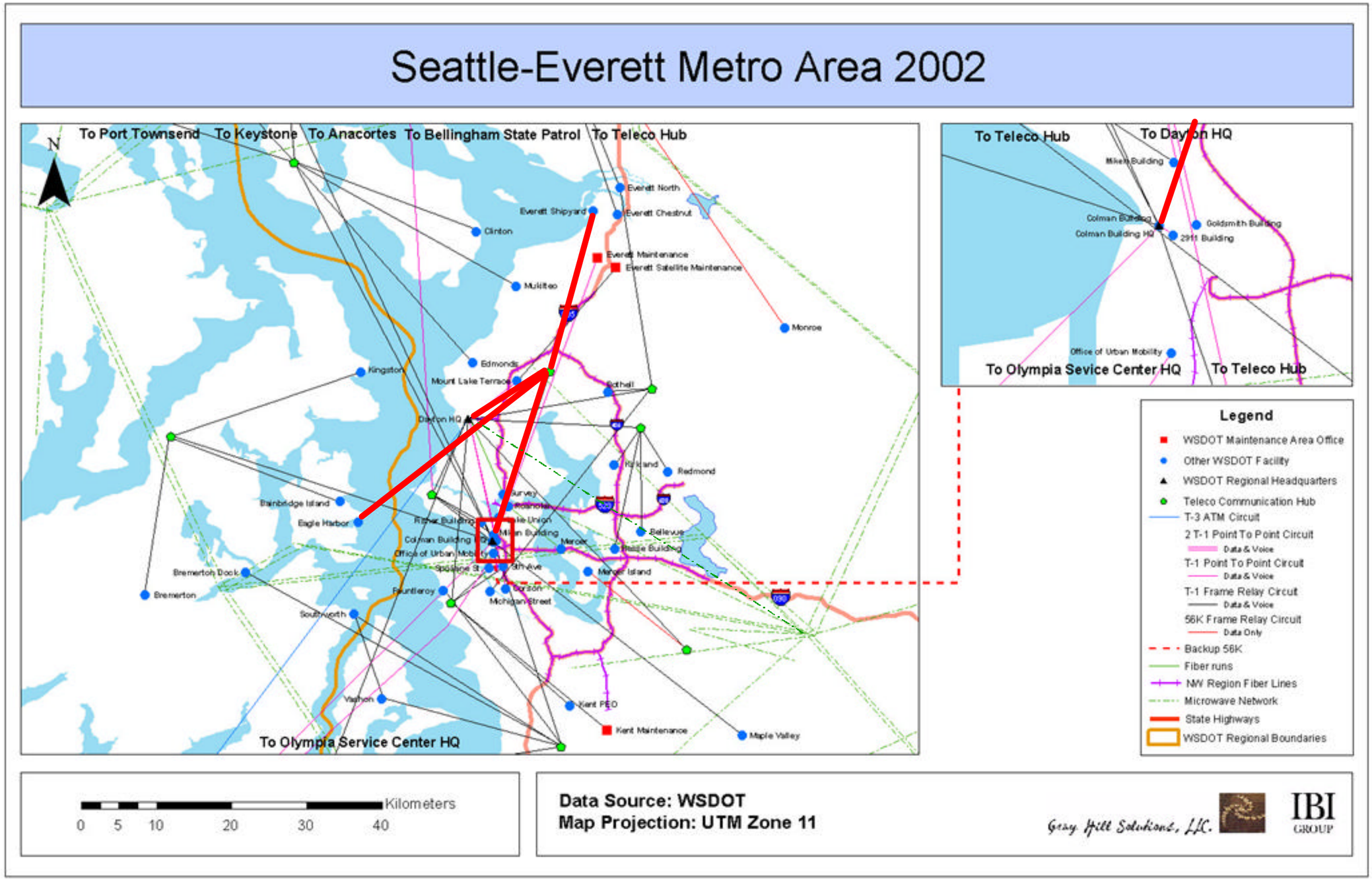


Figure 36: Seattle - Everett Metro Area Analysis Map

5.3 CENTER-TO-FIELD DATA AND VIDEO

Fiber optic cable has generally been installed as part of the Surveillance, Control and Driver Information (SCandDI) elements of freeway or HOV lane widening projects throughout the urban portions of the state. One of the key driving factors in determining when fiber is justified, is the density of devices that are existing or planned in a given section of roadway. Fiber optic cable is expensive to install and maintain, however, when a section of roadway has many devices the cost may be justified and the benefits three-fold:

- **Reduced operating cost**: Without the provision of state-owned communications infrastructure (such as fiber or wireless), each device requires a dedicated leased line or dial-up link. Higher bandwidth connections are required for video. Costs can become prohibitive when many devices are located in the same vicinity.

- **Quality of signal**: This is particularly important for CCTV cameras. When a low capacity leased line or dial-up option are only available, only snap shot or limited frame images can be received from the cameras.

- **Polling rates of data devices**: For low speed data devices, such as traffic sensors, RWIS, etc, fiber optic connections support much more frequent polling of the data.

Even when fiber can be justified due to density of devices, new construction can still be cost prohibitive. WSDOT has an informal policy in place, to "piggy-back" on to construction projects, such as lane widening, HOV lane construction, etc., to help reduce the incremental cost of construction of the communications infrastructure and ITS field equipment.

In an effort to determine rules of thumb for priority corridors for fiber optic construction, the data on ITS device locations (which was collected during the Light Lanes project) was analyzed and a series of maps were developed. These maps indicate "ITS Device Densities." The data collected in Light Lanes included both existing and planned ITS devices along the key WSDOT corridors.

The following rules were applied in developing these maps:

1. Roadways were analyzed in 5 mile segments

2. Device density was calculated as number of devices per mile, with the following parameters:

    - .1 to .4 Devices per Mile = Low Density
    - .4 to .7 Devices per Mile = Medium Density
    - .7 to 1.9 Devices per Mile = High Density
    - Greater than 1.9 Devices per Mile = Very High Density

3. Only High and Very High Densities were identified on the maps

Also included on the maps are the various WSDOT and WSP office locations. Another factor in determining where fiber is justified may be density of these offices. This fiber may be used as a backbone to connect various offices for both ITS and Enterprise data as discussed previously.

The analysis of these ITS device densities considered the following factors:

- Segments of "Very High" density of devices are a high priority for fiber construction.

- Segments of "High" density of devices, with a corresponding high density of offices are also a high priority for fiber construction.

- Segments of "High" density of devices, with few or no offices are medium priority for fiber construction.

- Segments of "Medium" or "Low" density of devices (and therefore not indicated on map) are low priority for fiber construction.

Figure 37 presents the Northwest Region ITS Device Density Map. The Very High density segments generally correspond with the existing SCandDI Fiber Ring around Lake Washington, including crossing both floating bridges. The only exceptions are Snoqualmie Pass (where WSDOT has a dedicated microwave network connecting devices) and south from the existing fiber ring to Tacoma (this segment carries on into the following map.

The density of WSDOT offices is generally in the downtown Seattle area. WSDOT already owns fiber along the DOT right-of-way through this area, so no new construction is recommended. (WSDOT may want to consider working with City of Seattle to use their fiber network in the city as "last mile" connections between their existing fiber ring and their offices.)

An argument could be made that extending the fiber network north to the Everett North facility might be justified, but further cost/benefit analysis would be required.

Figure 38 is the ITS Device Density Map for the Olympic Region. As discussed above, the segment of Very High density of devices continues south from the existing fiber ring in the Northwest Region, down to Tacoma. Therefore, this corridor may be considered high priority for fiber construction. This schematic only includes the regional offices, such as Maintenance area offices, Project Engineering offices and maintenance sheds. However, there are a number of other WSDOT facilities located in the Olympia region, including numerous headquarters facilities. Therefore, a specific map was developed focusing on the Olympia to Tacoma metro area.

Figure 39 is the ITS Device Density map for the Olympia – Tacoma Metro Area. This map illustrates two features:

- The existing fiber network in Tacoma (built by the Tacoma Fire Dept., but WSDOT has ownership of half of the fiber as discussed in another section)

- The high density of offices in the Olympia area.

The relevance of the existing fiber network in Tacoma is that the High Density segment terminates near the crossing of this existing fiber. Therefore, if fiber where built to this point, it would ensure connectivity between the Northwest SCandDI fiber network and the Tacoma fiber network

The relevance of the high density of offices in Olympia goes back to the recommended rule of thumb, i.e., high density of devices and high density of offices indicates high priority fiber segment. Again, WSDOT may want to work with the City of Olympia to use their growing city fiber network as "last mile" connections to connect to these offices.

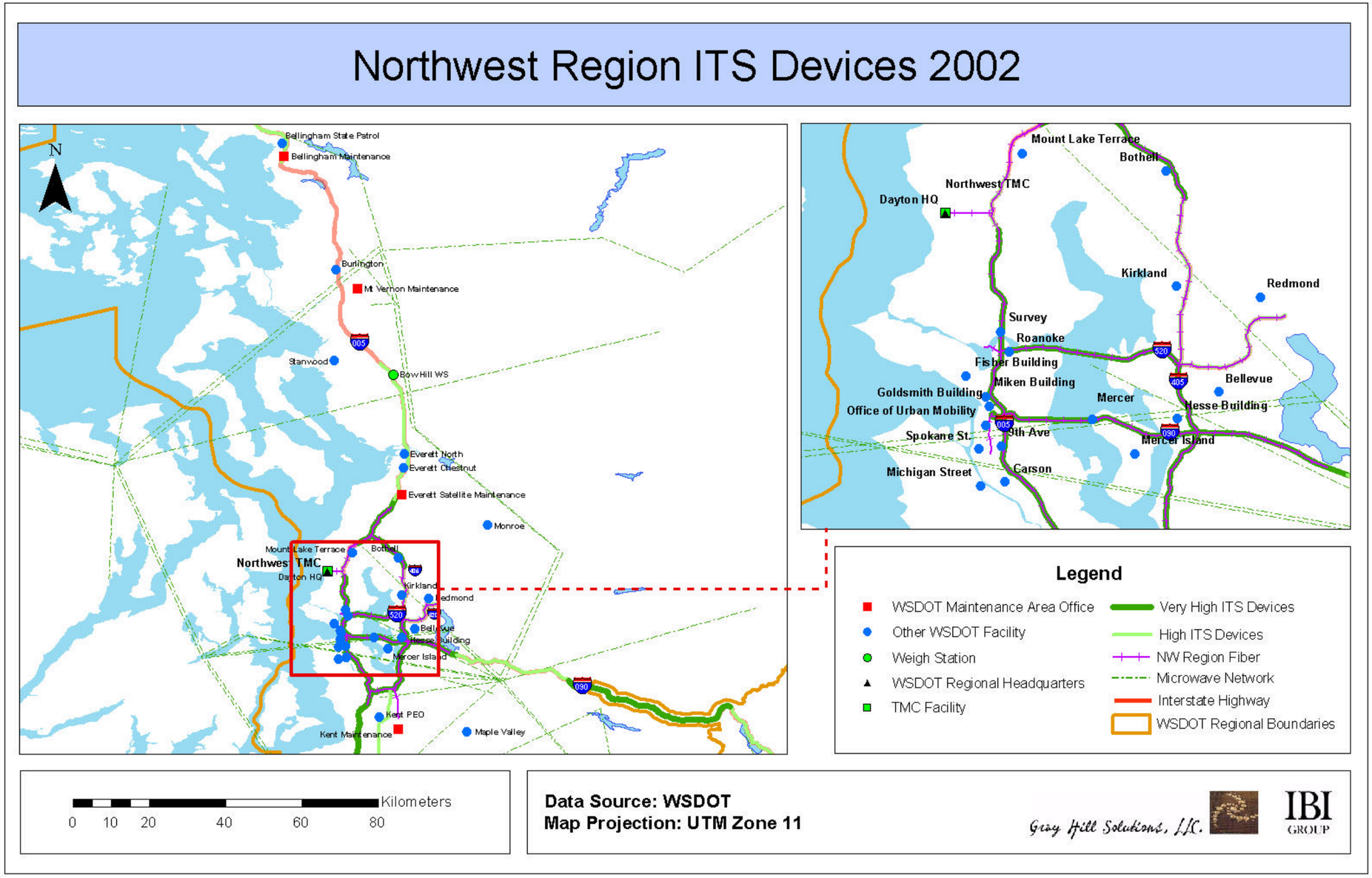


Figure 37: ITS Device Density Analysis Map – Northwest Region

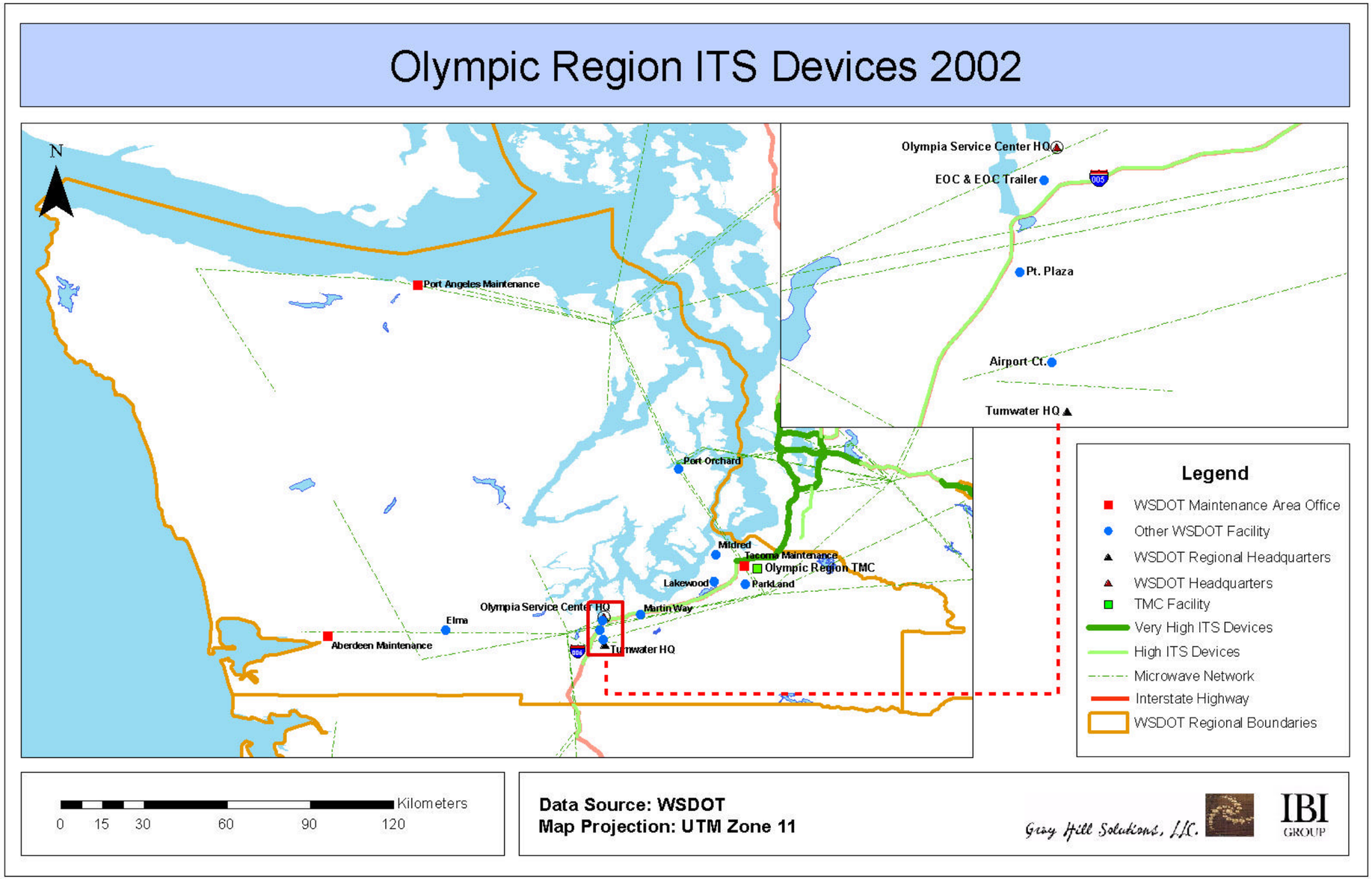


Figure 38: ITS Device Density Analysis Map – Olympic Region

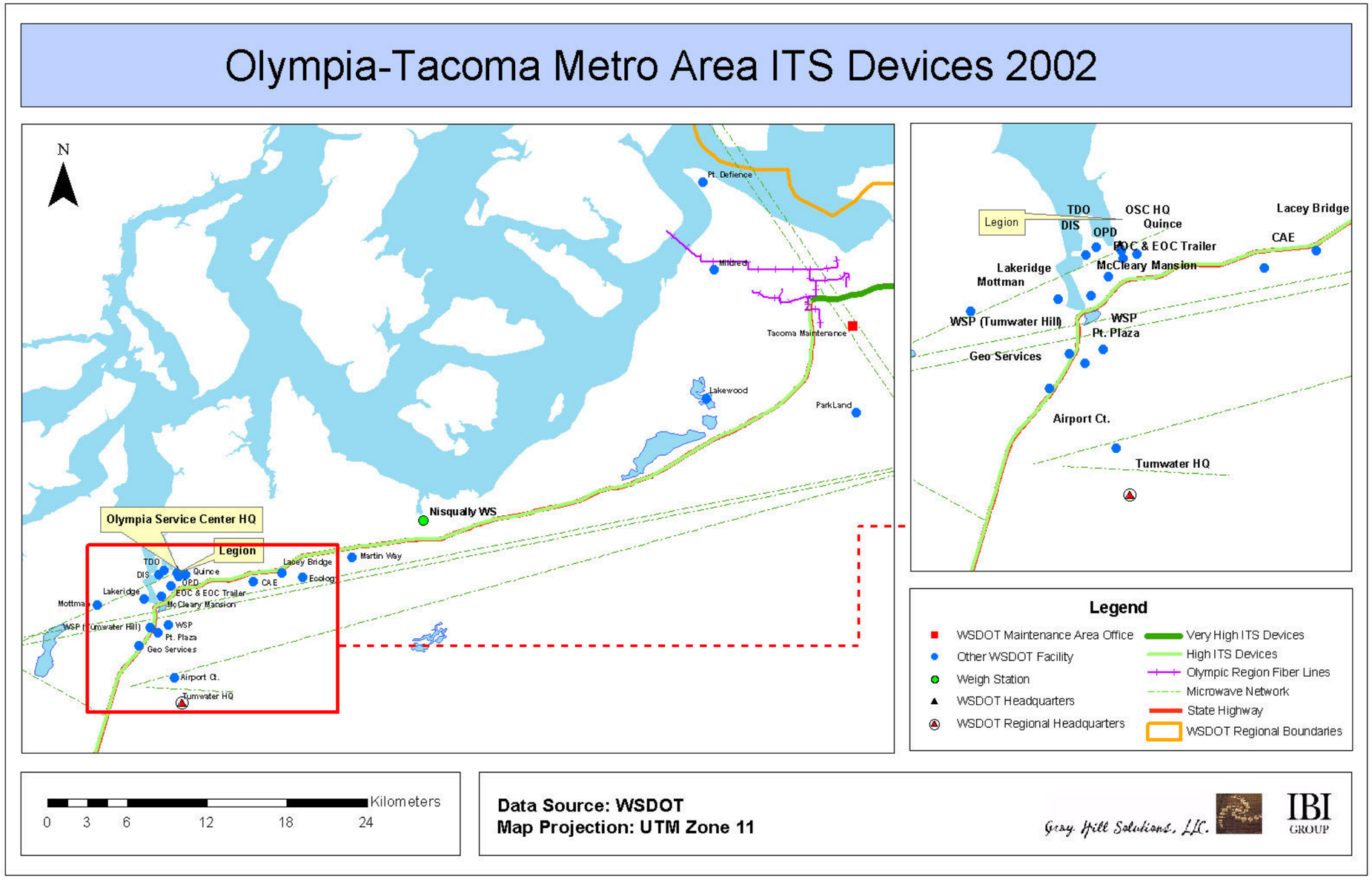


Figure 39: ITS Device Density Analysis Map – Olympia – Tacoma Metro Area

Figure 40 is the ITS Device Density map for Southwest Region. As illustrated on this map, the Very High density of devices form a triangle between I-5, I-205 and SR 14, extending a short distance up I-5 beyond the I-205 interchange. This triangle is therefore a potential high priority for fiber construction. The High-density segment from Ridgefield past Kelso also does not have a high density of WSDOT offices and is therefore a potential medium priority fiber construction segment, as is the small segment near Chehalis.

Figure 41 is the ITS Device Density map for the Eastern Region. As illustrated on this map, there is a Very High density of devices from west Spokane east to the Idaho border, therefore this may be considered a high priority for fiber construction. As illustrated on this map, there is a small segment of existing fiber in this region, some of which is included on this high priority corridor. The Geiger shed further to the west of Spokane is a low bandwidth site, and does not likely justify extending the fiber construction further west.

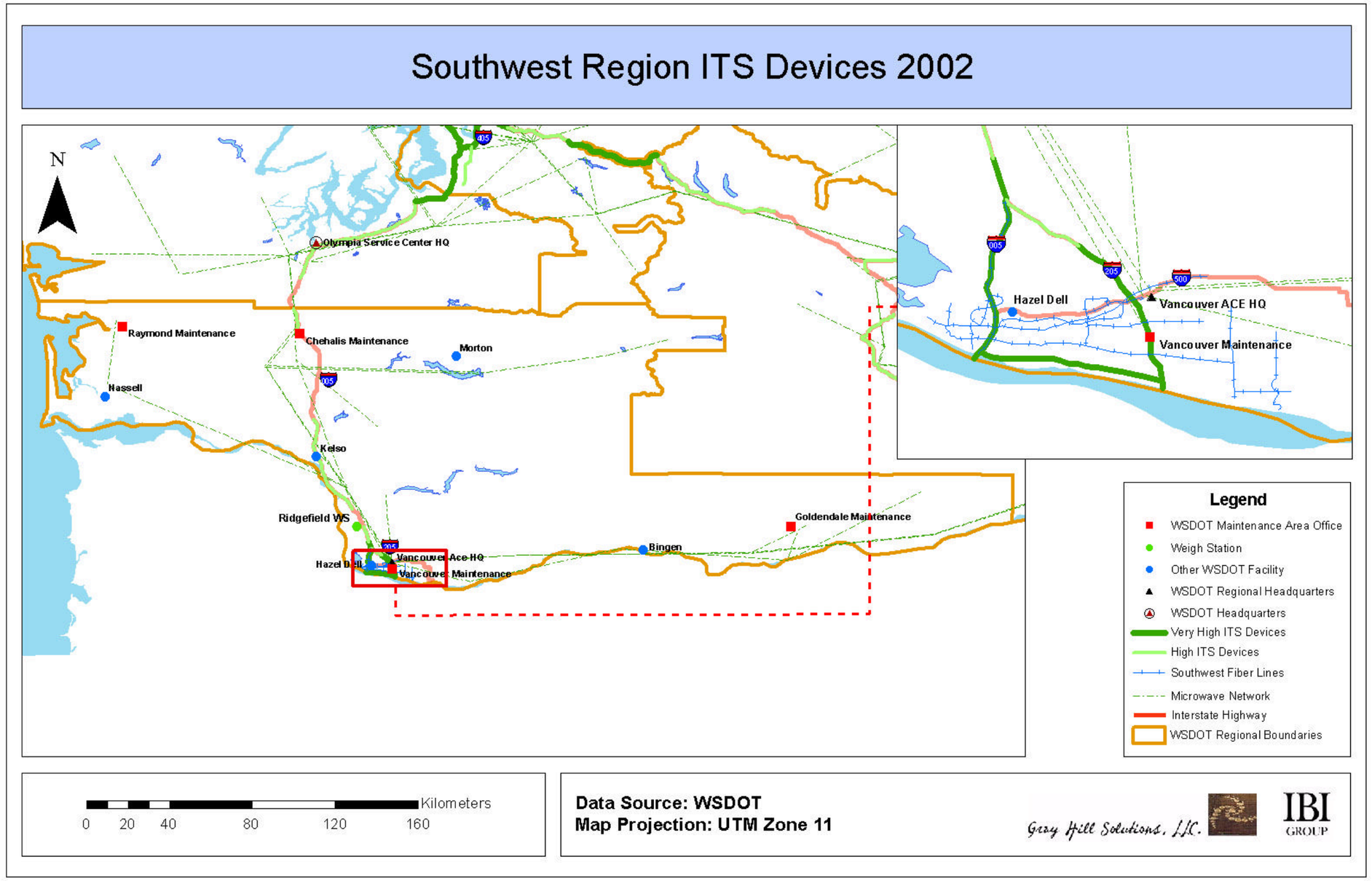


Figure 40: ITS Device Density Analysis Map – Southwest Region

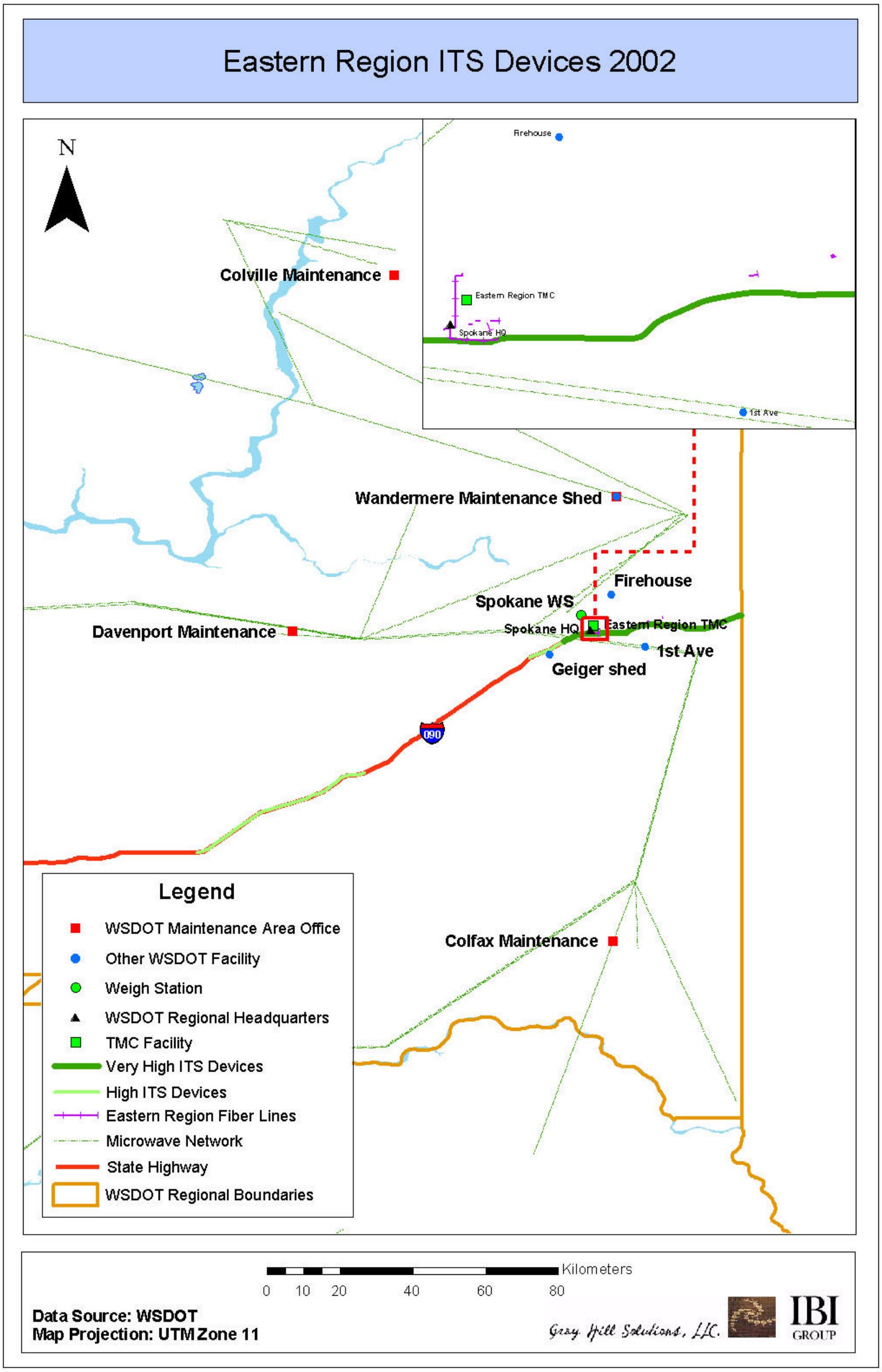


Figure 41: ITS Device Density Analysis Map – Eastern Region

6. RECOMMENDATIONS

This wide-ranging analysis of the existing communication networks, methods and future requirements reveals some excellent opportunities for cooperation and synergy with the promise of increased communication capacity, improved redundancy and lower operational costs. The needs and technical complexities are significant. Continuation of WSDOT's cooperative and active management will be required for success. In general terms, the WSDOT statewide communications network must serve all communication needs for daily and emergency operations with adequate capacity, redundant paths, and reliable service, while being cost effective. The network should remain a hybrid network (i.e., part state owned, part leased), but one that maximizes utilization of state-owned infrastructure, including the microwave, fiber, and radio networks. WSDOT should continue to use leased line communications where cost effective or where required for redundancy. Key specific recommendations are as follows:

6.1 RECOMMENDATION # 1: CREATE WSDOT/WSP COMMUNICATIONS TASK FORCE

Description

Develop a dual agency task force, including representatives from both WSDOT and WSP, whose charter is to make strategic decisions on communications infrastructure upgrades, lease/purchase options and new construction, while ensuring that both agencies' requirements are considered.

The task force may be broken up into different committees or groups to address specific issues and requirements. For example three groups may be created within the Task Force, possibly identified as:

- Customer Advisory Group: to focus on both agencies' communications needs and priorities,
- Technical Advisory Group: to focus on technologies, standards and design review,
- Executive (Governance) Group: to administer policy change as required, based on recommendations from the other two groups.

As with any effective task force within an organization, specific staff will need to be assigned the responsibility and authority required to ensure the effective implementation of any of the task force's recommendations.

Requirements Addressed

- Better coordination between WSDOT and WSP
- Microwave network design, upgrade and maintenance
- Procurement of new telecom services
- Design review for all wireless construction
- Provide cost effective network

Implementation Notes	Impact Areas
The following are potential tasks that the Task Force will undertake: 1. Review existing communications infrastructure for redundancy opportunities 2. Develop WSDOT/WSP long term and migration plan for the dual-agency network. WSDOT's priorities for upgrade may include high-utilization segments, Center-to-Center connections for ITS, and high-cost leased-line segments. 3. Review each deployment for compliance with plan 4. Review build/buy/lease arrangements to obtain best value	• Inter-regional Communications • Intra-regional Communications • Policy Issues

5. Develop necessary agreements. 6. Develop a Wireless Subcommittee to review the planning and design of all wireless construction projects. 7. Review "siting" of field equipment to ensure that opportunities for collocation and other efficiencies (line of site, power, etc) are maximized. Consider starting with the Statewide Communications Plan Task Force and growing as appropriate.	**Correlation with Other Recommendations** • #2 – Upgrade Microwave Backbone

6.2 RECOMMENDATION # 2: UPGRADE MICROWAVE BACKBONE

Description

Work together with WSP to upgrade key segments of Microwave segments to OC3. Figure 21 illustrates the segments of the microwave network that WSP has identified as priorities to upgrade in order to complete three OC3 rings.

Requirements Addressed

- Better redundancy for key inter-regional connections
- Upgrade segments that are at/near capacity
- New connections to WSP
- Upgrade microwave backbone as voice traffic increases.
- Support growing bandwidth requirements on existing links
- Need selected center-to-center TMC ITS links
- New Statewide Traffic Operations Center
- Provide cost effective network

Implementation Notes

The upgraded microwave network will be used for data and voice and possibly video. In addition to the expanded bandwidth, the upgrade will help to improve redundancy for key connections.

WSDOT should prioritize their communications requirements, to be able to work more effectively with WSP, particularly, to be able to quantify the bandwidth requirements and the type of communication (data, voice, video) to be supported.

Jointly, the agencies may be able to identify opportunities to modify and improve the plan illustrated in Figure 21. For example, state owned sites may be identified as preferable to any leased sites that may be indicated in the figure.

Upgrade requirements to equipment, towers, facilities and/or cable plant should all be taken into account, along with agency communications needs, when determining the final paths and associated sites to be upgraded.

Impact Areas

- Inter-regional Communications
- Intra-regional Communications
- Center-to-Field Voice
- PBX Network

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force

6.3 RECOMMENDATION # 3: UPGRADE OVER-UTILIZED COMMUNICATIONS LINKS

Description

Specific links that provide communications to WSDOT offices are over-utilized, resulting in a reduced level of service. Benefit/cost analysis should be performed comparing adding additional leased line capacity vs. upgrading and utilizing existing infrastructure, particularly the fiber and microwave networks. This analysis needs to compare life cycle, in addition to, initial capital construction costs.

Requirements Addressed

- Better redundancy for key inter-regional connections
- Upgrade segments that are at/near capacity

Implementation Notes

Figure 6 is a graph illustrating current bandwidth utilization rates of all of the key Inter-regional connections, i.e., between WSDOT HQ in Olympia and the regional HQs.

Figure 16 is a graph illustrating the moderate and high utilization Intra-regional connections.

Figure 28 through Figure 36 illustrate some examples of potential microwave paths, which may be upgraded to be able to replace or augment the leased line connections at many of these "high utilization" segments. Figure 37 also illustrates the existing fiber network in the NW region.

It is recommended that upgrade of these segments of owned infrastructure (microwave and fiber) be considered and compared (cost/benefit analysis using life cycle costs) with leased line options, as WSDOT decides to upgrade these segments.

It should be noted, that the upgrades that are currently underway with NoaNet and Quest (as described in section 3.1.4 and illustrated in Figure 7) should go a long way toward addressing many of these high utilization segments, particularly the Inter-Regional segments.

Impact Areas

- Inter-regional Communications
- Intra-regional Communications

Correlation with Other Recommendations

- #2 – Upgrade Microwave Backbone
- #4 – Review WSDOT-owned Fiber Capability to Support IT
- #5 – Explore options with 360networks fiber on I-5

6.4 RECOMMENDATION # 4: REVIEW AVAILABILITY OF WSDOT FIBER FOR USE BY IT/IS

Description

WSDOT has an extensive fiber optic network in the Northwest Region and growing networks in other regions including Olympic, Southwest, and Eastern. These networks, built originally to support ITS communications, should be analyzed for potential to support WSDOT's wider communications needs including ITS, as well as, administrative and IT/IS data, video and voice requirements.

Requirements Addressed

- Need selected Center-to-Center TMC ITS links
- New Statewide Traffic Operations Center
- Provide cost effective network

Implementation Notes

As with many regions around North America who were earlier implementers of ITS technologies, the WSDOT Northwest Region's fiber network was designed and implemented utilizing technology (and associated architecture) that was considered "state of the art" at the time.

Advances in communications technology have lead to much more efficient utilization of infrastructure, most notably fiber optic plant. Nowhere is this more evident than in the transport of video signals from a field device (CCTV camera) back to the TMC. Older technology often required dedicating an entire fiber to a single camera. Advanced in multiplexing, digitize and compression technologies, now offer the ability to combine and transport many signals (as well as data) on a single fiber.

It is recommended that WSDOT review their fiber networks for opportunities to optimize network utilization, thus freeing up fiber to be used for other communications needs. The review should consider existing dark fiber, "re-grooming" of lit fiber, and any associate electronics and optronics upgrades as required. The cost of these upgrades and the regrooming efforts could then be shared between the IT department and the ITS group as appropriate.

Impact Areas

- Inter-regional Communications
- Intra-regional Communications

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #3 – Upgrade Over-utilized Communications Links
- #9 – Formalize Fiber Policy for New WSDOT Construction Projects

6.5 RECOMMENDATION #5: EXPLORE OPTIONS TO LEASE 360NETWORKS FIBER ON I-5 AND EXPLORE OPPORTUNITIES WITH OTHER PROVIDERS

Description

360networks has expressed interest in long-term lease options for dark fiber currently running from Vancouver to Everett. 360networks also indicated possibility of installing additional manholes or splice points if required. This opportunity should be further analyzed.

Additional telecommunications market research may also identify other providers willing to offer long-term lease or dark fiber sales.

Requirements Addressed

- Need selected Center-to-Center TMC ITS links
- New Statewide Traffic Operations Center
- Support growing bandwidth requirements (specifically, video)
- Provide enterprise-wide communications solutions
- Provide cost effective network

Implementation Notes

One of WSDOT's desires in this study was to see if any telecommunications providers were willing to sell and/or enter into long term lease agreement on, dark fiber along WSDOT's key corridors. This fiber could then potential be used for both center-to-center and center-to-field communications.

At the time that this study was completed, only 360 networks had indicated interest in a long-term lease or 20-year IRU (Indefeasible Right-of-Use) agreement, for two fibers along the I-5 corridor, primarily from Vancouver to Everett.

Appendix D illustrates 360 networks approximate fiber route along this corridor (note: No fiber along stretch of I-5 between Chehalis and Spanaway, as it follows a separate route up to several miles away from I-5.)

Appendix E includes a sample 360networs agreement letter, including a preliminary fee estimate for the IRU. It should be noted that 360networks provided this estimate as a "lump sum" (or capitol cost) for the 20-year IRU (as requested.) 360networks indicated that this agreement could be easily structured in monthly payments.

It should be noted that this telecommunications market review was not a significant portion of the overall Statewide Communications Plan and therefore was not an "exhaustive" exercise. Oregon DOT has apparently had more success with other telecommunications providers and may be able to provide additional contacts.

Impact Areas

- Inter-regional Communications

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #4 – Review WSDOT-owned Fiber Capability to Support IT
- #9 – Formalize Fiber Policy for New WSDOT Construction Projects

6.6 RECOMMENDATION # 6: BANDWIDTH MANAGEMENT FOR VIDEO

Description

There are techniques (and equipment) that can dynamically manage the bandwidth utilized for the transmission of digital video images, which "expand or contract" the bandwidth to meet the current need, priorities and available bandwidth. These techniques could be used to reduce the demand on the communications network for the transmission of the video images to WSDOT Headquarters for placement on the WSDOT traveler information website.

Requirements Addressed

- Support growing bandwidth requirements.
- Increased center-to-field communications requirements.
- Increase spare capacity

Implementation Notes

Bandwidth management is a phrase that is gaining increasing popularity with IT professionals, and encompasses a set of technologies and techniques that have great promise to more effectively and efficiently utilize existing communications infrastructure and investment. Many of these techniques and technologies should be considered for further evaluation by WSDOT.

Bandwidth management (BWM) tools can prioritize data traffic based on user defined "classes", to ensure that high priority communications traffic can not be bottlenecked by lower priority traffic (a technique known as class based queuing or CBQ). Other BWM products allocate bandwidth based on the usage by individual data flows (a technique known as "fair queuing.") Still others involve matching the type and speed of a given data stream to the specific "receiving" connection available, whether it be 28.8K modem, T1 line, etc. Technologies in BWM continue to improve and some products now combine this bandwidth matching functions with the data prioritization functions.

One type of implementation of bandwidth management that could prove very beneficial to WSDOT could be the implementation of a digital video distribution system, to better manage flow of video information to other municipalities and to the general public. A system like this would be fully digital, providing video in a range of bandwidth options, by varying the resolution (from still frame capture to 5 to 30 frames per second), based on available bandwidth. The system would then match the output based on the receiving entities bandwidth capabilities. Many other applications are available that should be further analyzed.

Impact Areas

- Center-to-Field Video

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #4 – Review Adequacy of WSDOT Fiber Available for IT

6.7 RECOMMENDATION # 7: USE RADIO FOR FIELD DEVICES

Description

Look for opportunities to use the radio network to communicate with field devices instead of leased line communications. Opportunities may exist with the current 800MHz radio network, particularly for low data devices and/or remote areas. Many more opportunities will become available if and as WSDOT migrates to 700MHz band.

Requirements Addressed

- Increase center-to-field bandwidth availability
- Provide cost effective network

Implementation Notes

Current 800MHz Network
Identify specific opportunities within each region where field devices that are currently utilizing leased line communications (especially dial-up service) may be able to be replaced using the existing radio communications network.

Particular sensitivity needs to be placed on ensuring that the 800MHz network is not over-burdened, as voice communications to field personnel are considered top priority, mission critical services. Accordingly, opportunities may only be available for devices that require very low data transfer rates (such as turning beacons on and off) and/or devices that are located in remote areas, where there is very little voice traffic on the radio network.

Analysis should include cost comparison of life cycle leased line cost vs. equipment upgrade, maintenance requirements, bandwidth limitations and coverage/interference issues. illustrates the WSDOT Radio network, including the identification of areas of poor coverage and interference.

Future 700MHz Network
Migration to the 700MHz band promises to extensively increase bandwidth availability. WSDOT should perform an inventory of ITS field devices (existing and proposed) within each region, as well assigning bandwidth requirements to each device type. This inventory should then be considered during network deployment, to identify opportunities to expand utilization of the radio network to communicate with field devices.

Impact Areas

- Center-to-Field Data
- Center-to-Field Voice

Correlation with Other Recommendations

- #8 – Radio Upgrade

6.8 RECOMMENDATION # 8: RADIO UPGRADE

Description

Support Wireless Task Force recommendation to upgrade radio network to 700 MHz band.

Requirements Addressed

- Need to upgrade 800MHz radio network due to interference with NexTel
- Increased center-to-vehicle bandwidth availability
- Increase center-to-field bandwidth availability
- Create redundant connections between all regional HQ and regional Maintenance Area Offices

Implementation Notes

This recommendation addresses interference problems with NexTel and provides additional bandwidth for data to vehicles and field devices. The analysis of this option must be finalized and a phased implementation plan and "exit strategy" developed.

Consider trying to negotiate with NexTel for a "fee for spectrum" to help offset the costs of this upgrade and migration. NexTel and other carriers have been known to help share the cost for other agencies to migrate out of the 800MHz spectrum, but it will require negotiation.

While WSP does not plan on migrating their voice radio to the 700Mhz band, they have show interest in utilizing the 700 band for data communications to support applications such as email and Internet access to the vehicle, including transfer of records to the vehicle.

Impact Areas

- Center-to-Field Data
- Inter-regional Communications
- Center-to-Field Voice

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #7 – Use Radio for Field Devices

6.9 RECOMMENDATION # 9: FORMALIZE FIBER POLICY FOR NEW WSDOT CONSTRUCTION PROJECTS

Description

Formalize policy of installing fiber along any roadway widening or "HOV lane addition" projects. To support this, key routes should be identified and prioritized and standards for installation of fiber and/or conduit for WSDOT communication should be developed and implemented.

Requirements Addressed

- Better documentation of infrastructure and asset management
- Support growing bandwidth requirements
- Provide cost effective network

Implementation Notes

WSDOT currently has an informal policy in place to install conduit and/or fiber in specific roadway widening and HOV projects. This is a very valuable practice, as the incremental cost of installing infrastructure during and existing construction project is many times lower than the cost of deploying a "stand alone" communications infrastructure installation project. However, since WSDOT does not have a formal policy in place, the installation of communications infrastructure is often considered an expendable item, which is then often cut from the project when budgets are tight.

It is recommended that WDOT formalize this policy by assigning specific "priority corridors" for infrastructure installation and develop standards for installation of fiber and/or conduit in these corridors. Figure 37 through Figure 41 include maps of "ITS device densities" and may be utilized to help prioritize these corridors. The maps illustrate segments of WSDOT roadway and classify them as "Very High ITS Device" density, "High ITS Device" density or no classification (which therefore indicates lower density of devices.) Figure 37 and Figure 39 also indicate a high density of WSDOT offices, which should also be considered in corridor prioritization.

There is considerable flexibility in the way that WSDOT ultimately chooses to assign corridor prioritization. For example, it may be determined that any corridor of "Very High Device" density be considered as mandatory fiber installation, while any corridor of "High ITS Device" density be considered "conduit only" or even "optional based on budget availability." Whatever the decision, clear guidelines and specific standards should be developed and the policy should be widely enforced.

Impact Areas

- Policy Issues

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #4 – Review WSDOT-owned Fiber Capability to Support IT

6.10 RECOMMENDATION # 10: CONDUCT I-5 CORRIDOR COMMUNICATION ANALYSIS

Description

Develop, compare and price alternative methods for providing communication services along I-5 corridor.

Requirements Addressed

- Provide enterprise-wide communications solutions
- Need Selected Center-to-Center TMC ITS Links
- New Statewide Traffic Operations Center
- Support growing bandwidth requirements (specifically, video)
- Better redundancy for key inter-regional connections
- Provide cost effective communications

Implementation Notes

Examine Seattle to Olympia and Olympia to Vancouver segments.

Conduct detailed analysis of life-cycle cost trade-off between leasing, microwave, and new fiber construction

Recommended Tasks Include:

1. Investigate specific routes and connectivity requirements with vendors to determine availability of services
2. Solicitation of firm quotes from selected telecommunication service providers
3. Development of complete cost comparisons including existing leased lines, potential dark fiber providers and extension of a state-owned fiber network. This analysis should consider capital costs, operating expenses, and life cycle replacements.

Impact Areas

- Inter-regional Communications
- Intra-regional Communications
- Center-to-Field Voice
- PBX Network

Correlation with Other Recommendations

- #2 – Upgrade Microwave Backbone
- #4 – Review Adequacy of WSDOT Fiber Available for IT
- #5 – Explore options with 360networks fiber on I-5

6.11 RECOMMENDATION # 11: IMPLEMENT ASSET MANAGEMENT POLICY

Description

Develop a policy and procedures for Asset Management.

Requirements Addressed

- Better documentation and asset management

Implementation Notes

The first implementation stage to this recommendation would determine the range of assets that should be managed. This determination must consider the cost of recording and maintaining each group of devices, and cost effective methods to record and maintain a current inventory of the designed equipment and associated information.

Potential information to be included in the Asset Management system:

- Fiber, communications equipment, ITS devices, etc.
- Include location, type of device, part number, warrantee info, and maintenance information.
- All part assignments and use of communication channels.
- Include communications connections type and cost.

The second stage of implementation would develop high-level procedures for the initial data collection and/or input, to add assets acquired under capital projects, and to maintain current records in the event of maintenance and repair activities.

This recommendation should also consider the technologies and hardware required to implement, maintain, and provide user access to the Asset Management System.

It is understood that WSDOT currently has an asset inventory tool, however the extent to which it is utilized, and the features that it includes are not fully known. This existing tool should be investigated as part of this effort.

Impact Areas

- Policy Issues

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force

6.12 RECOMMENDATION # 12: EVALUATE SATELLITE FOR REMOTE SITES

Description

Evaluate findings from Eastern Region test use of satellite to remote field offices.

Requirements Addressed

- Provide enterprise-wide communications solutions
- Provide redundant connections between all regional HQ and all regional maintenance area offices.

Implementation Notes

Eastern Region plans on upgrading up to 16 maintenance sheds to include network connectivity utilizing satellite broadband connections. WSDOT has tested these satellite broadband connections at several sites, and has decided to proceed with full-scale deployment.

Eastern Region investigated other options for replacing the dial-up service to these maintenance sheds (many of which were at 28.8K speeds), but found that in most cases satellite broadband was the only option, due to service availability. Rather than split their network between some DSL, some cable broadband and some satellite, they decided to standardize as much as possible with one vendor and one solution.

It is recommended that WSDOT review the results of this implementation with Eastern Region, and determine if it is a viable solution for remote sites in other regions, particularly North and South Central.

Impact Areas

- Inter-regional Communications

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force

6.13 RECOMMENDATION # 13: REDUNDANCY

Description

Develop a standard strategy to implement redundancy to larger offices.

Requirements Addressed

- Reliability
- Flexibility
- Better redundancy for key inter-regional connections
- Provide cost effective communications

Implementation Notes

Establish a policy for providing redundancy

Set requirements for use of multiple technologies (e.g., microwave, leased lines, VoIP)

This recommendation calls for the development of standards that establish which facilities require redundancy. The standards should consider size of the office, types of applications, and cost effectiveness. The standards should be developed for application at any time in the future (as conditions change), not just a one-time determination of facilities requiring redundancy.

The strategy for redundancy should also address the types of redundancy that are available, including;

- route redundancy
- equipment redundancy
- redundant technologies
- "emergency" backups that may not provide redundancy for 100% of the network loading

Impact Areas

- Network Policy

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force
- #2 – Upgrade Microwave Backbone
- #8 – Radio Upgrade

6.14 RECOMMENDATION # 14: SPARE CAPACITY GUIDELINES

Description	
Establish guidelines for spare capacity in WSDOT-owned networks.	
Requirements Addressed	
• Flexibility • Provide cost effective communications	
Implementation Notes	**Impact Areas**
Spare levels for a number of different aspects of the network should be developed, including: • Bandwidth in the provisioned network. • Space in Equipment Chassis to provide additional cards for increased capacity. • Spare fibers or twisted pairs in cables that are installed underground. • Space for expansion in buildings, equipment racks and field cabinets Different spare capacity guidelines could be developed according to expected growth areas, and recognize technologies of different life cycles.	• Network Policy **Correlation with Other Recommendations** • #1 – WSP/WSDOT Communications Task Force • #9 – Formalize Fiber Policy for New WSDOT Construction Projects

6.15 RECOMMENDATION # 15: COMMUNICATION PROTOCOLS

Description

Adopt standard communication protocols for WSDOT applications and equipment.

Requirements Addressed

- Equipment Standards
- Communication Standards

Implementation Notes

Adopt standard communication protocol to reduce the complexity of the network. The following protocols are recommended:

- TCP/IP networks should be used for the majority of the lower speed (10/100Mbps) connections.
- High-speed communication should use SONET transmission standards. This equipment can be fed with the T1 and DS-3 signals standard to the telephone industry.
- Where networks carry TCP/IP traffic only, consideration should be given to the use of Gigabit Ethernet for backbone communication.
- Low speed data circuits (primarily for ITS applications) can use EIA/TIA 232 or TCP/IP.
- All ITS interfaces should adhere to NTCP/IP standards where they have been accepted. All data interfaces should use EIA/TIA 232 and/or Ethernet protocols, which will support NTCIP standards.
- Consider the use of Gigabit Ethernet for TCP/IP is used and dark fiber is available

Impact Areas

- Network Policy

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force

6.16 RECOMMENDATION # 16: COORDINATION WITH MAINTENANCE

Description

Implement a policy of closer coordination with Maintenance during the design and implementation of communications projects. The intent of this policy should be to ensure early identification of the group or individuals who will be responsible for the on-going maintenance and operations of the communications infrastructure. Once the proper parties have been identified, effort should also be made to make sure that they have been included in the design review process and that they have the proper tools and training for ongoing infrastructure Operations and Maintenance.

Requirements Addressed

- Equipment Standards
- Communication Standards
- Provide cost effective communications

Implementation Notes

1. Identify who will be maintaining the equipment (may very by network component).
2. Review system design with maintenance personnel at appropriate point in design process.
3. Ensure that maintenance personnel have the necessary technical training and equipment to support ongoing O & M, and if not,
4. Investigate opportunities for contracted maintenance where most applicable, particularly with fiber optic plant.
5. Consider procuring the equipment needed to maintain the networks built under capital contracts as "test equipment supplied by the contractor" for these projects.
6. Review maintenance budget and assigned FTEs to ensure that O & M is supported.

Impact Areas

- Network Policy

Correlation with Other Recommendations

- #1 – WSP/WSDOT Communications Task Force

APPENDIX A: STATEWIDE TRAFFIC OPERATIONS CENTER DISCUSSION

WSDOT STATEWIDE TRAFFIC OPERATIONS CENTER (STOC)

Discussion on functionality and space needs

This is information for discussion for considering the operational focus and space requirements of a statewide traffic operations center located at Headquarters.

Pete has already done a good job of documenting what he calls the goals of the center. This information is attached at the end of this document. For this discussion Pete's goals for the center are incorporated under the possible center FUNCTIONS listed below that globally encompass monitoring, integration, and control.

POSSIBLE FUNCTIONS

Existing Web and Media Information Monitoring Function

Access to all of the existing web based information about traffic, travel, and weather around the state. The information would consist of what WSDOT currently has on the web (CCTV, weather, FLOW, incidents, mountain passes, etc.) as well as other transportation agencies have, other non-transportation agencies (NOAA, NWS, Coast Guard, etc), and what the media has.

There could also be a desire to have access to local broadcast news around the state. However, getting broadcast news from stations around the state to the STOC may be difficult.

This function would allow someone at the STOC to monitor what is happening statewide based on information sources that exist today. To fully integrate all of the information that currently exists on the web so it could be efficiently accessed at the STOC would require developing an extensive system of links and customized pages for accessing and organizing these links.

New Sources of Information (Data Integration) Function

Another function of the STOC could be to take existing transportation raw data (TDO data stations, transponders, tags, etc) currently not used for operations or travel information and develop applications to transform this data into useful operations or public travel information. TDO data station data could provide a rural, statewide flow map. Tags and transponders from our CVO efforts could be used for travel time determinations for areas that do not have loop detectors.

Other sources of data that may become available in the near to mid term are IRT and service patrol vehicle location and snow plow location data.

Software applications would need to be developed to make much of this data integration possible.

Existing WSDOT Systems Monitoring and Control Function

With the coming development of the statewide HAR network, this function could possibly allow someone at the STOC to actively use the system to provide travel information from a statewide perspective. The CARS systems in another such tool, it is operational today.

New WSDOT Systems Monitoring Function

New systems that may be available in the future that could permit a statewide monitoring function from the STOC are a statewide VMS message status system and a statewide shared CCTV camera control access system. These systems do not exist and there are no plans at this point to purse them.

OPERATIONS SCENARIOS

Once the functions of the STOC are determined, it will help define the OPERATIONS elements of the center. These represents what the center will actually do. Possible operations elements include:

Radio and Systems Operations

- Become the radio operations and phone coordination point between WSDOT and other agencies (WSP, counties, etc) on a statewide basis in a time of need.

- Become a statewide operations center by accessing systems that have statewide reach (like HAR) and by actively communicating with regional centers to coordinate operations on a multiregional bases when needed.

These types of operations could be done on an as needed basis when significant events occur around the state to warrant the operations. They could also be done on a full time basis to move toward continuous statewide coordinated operations. Therefore, staffing could range from as needed up to a 24/7 operations.

Public Information Operations

- Become the statewide media contact point for information related to events, incidents, problems that have a statewide impact or generate a statewide interest.

- Become the statewide CARS administration center and also become the location where data is entered into CARS for events that require multi regional coordination.

- Become the 511-system central administration/monitoring point.

These types of operations would require staffing of the center on a continuous basis, either during business hours or as much as 24/7.

Emergency Response Operations

- Become the new WSDOT HQ EOC

This type of operations could be done on an as needed basis when significant events occur around the state to warrant the operations. Staffing would be as needed. Staffing needs could include radio operations, media/public information contact, and possible systems operations staff.

CENTER LAYOUT AND SPACE REQUIREMENTS

Based on the preceding discussion of possible functions and operations of the STOC recommendation for the center conceptual design includes the following elements. These layout and space requirements will need to be adjusted as final decisions on center functions and operations are made

Proposed Layout

The center would include 3 separate areas (see diagram below).

- *The monitoring floor*, would have 4 workstations, one for radio and systems operations, two for public information/CARS/511 operations, and one EOC command desk. The monitoring floor will have a video wall accessible by all of the workstations. An additional workstation could probably be accommodated depending on how the floor layout is designed.

- *The observation room*, would be comprised of a small conference area and observation area isolated from the monitoring floor. The observation room would be separated from the monitoring floor by a door and glass observations window. It would provide space for strategy and coordination discussions when needed and a space for tours and observation of the monitoring floor . The room should be equipped with multiple phone and computer hook ups to expand the functionally of the center when needed.

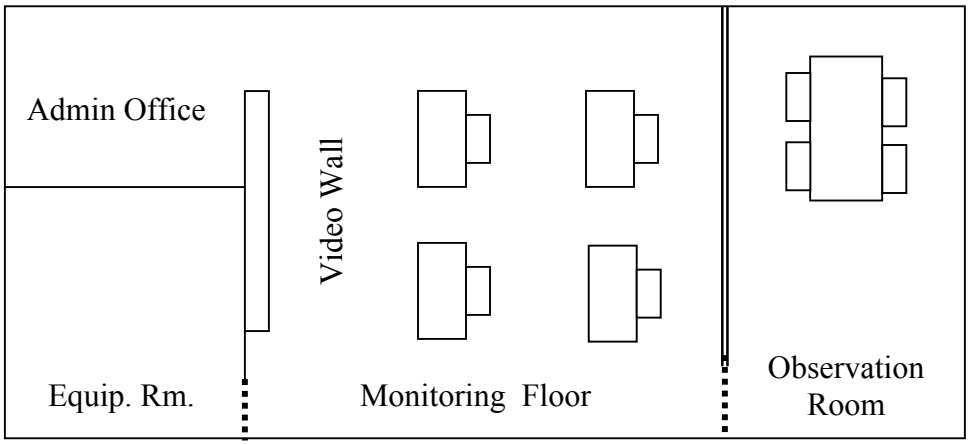
- *The equipment room*, provides space for servers, radios, other equipment and possibly a STOC administration office/station.

Estimated space requirements

Work floor:	500 sf
Observation room	250sf
Equipment room:	250sf
Total	**1000sf**

As points of reference, the NWR TSMC is approximately 6000sf for the entire facility, which includes radio operations, the monitoring floor, the observation room, equipment room, etc. The SCR Operations Center has approximately 350sf, 200 for the monitoring floor (2 work stations and the video wall) and 150sf of equipment room space.

STOC SIMPLIFIED LAYOUT CONCEPT
As illustrated, approximately 20’ x 50’



Notes from Pete Briglia, WSDOT, Advanced Technology Branch:
WSDOT Statewide Operations Center would have the following goals:

- Collect information on the performance of the state highway system. The data to be collected may consist of:
- Detector data from the freeways in each region would be sent to a central database over the Internet.
- Volume and speed data from TDO data stations
- Transponder tag data from the CVISN database
- Statewide incident data from the CARS database
- Roadway, ramp and lane closure data (construction closures) from the CARS database
- Audio files of current HAR messages
- Current VMS messages
- Snowplow/Sanding truck locations with de-icer application rates
- Infrastructure security information
- WSDOT fleet (including IRT trucks) location information

- Provide a statewide view of travel conditions for the long distance traveler. All data would be geocoded and displayed in layers. Web pages would display: (NOTE: not all of this would be displayed to the public)
- Links to urban traffic flow maps. The button or link would flash or somehow indicate when there is significant urban congestion.
- Rural spots speeds from TDO data stations
- Urban and rural travel times. (Urban travel times will be determined from detector data and rural travel times from CVISN tag data.)
- CARS incident page
- CARS construction page
- Statewide surface temperatures from Traffic and Weather page
- Mountain Pass conditions
- HAR locations with clickable icons to play messages
- VMS locations with clickable icons to display messages
- Statewide Maintenance Decision Support System with plow locations, areas recently plowed, sanded or treated with deicing chemicals.
- Video from cameras currently posted on the web. (Selected freeway cameras, mountain pass and construction zone cameras.
- Evacuation routes with sequenced video along the routes.
- Infrastructure security status
- Fleet location data (including IRT trucks and service patrols

APPENDIX B: CURRENT WSDOT ITS PROJECTS

PROPOSED ITS PROJECTS FOR WASHINGTON STATE: MARCH, 2002

Contact:
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This list reflects the priorities of our ITS program which include the deployment of Advanced Transportation Management Systems (ATMS) and Advanced Traveler Information Systems (ATIS). Areas of priority within the ATMS category include the deployment of freeway management infrastructure and the integration of WSDOT and local agency traffic signal systems. In the ATIS category, our priority is the deployment of systems to improve safety in rural areas by warning motorist of adverse weather and road conditions.

SAFETY PROJECTS

TITLE: CRITIAL DATA COMMUNICATIONS SYSTEM ENHANCEMENT
OBJECTIVE: The WSDOT/WSP statewide communications microwave backbone is critical infrastructure both for routine day-to-day activities and during emergencies. The system carries business, operations, and public safety communications and data. As WSDOT and WSP move to coordinate statewide operations to better respond to critical needs, a more sophisticated communications infrastructure is needed. This project will enhance the most critical link within the statewide system to permit higher data capacity and more secure data transmission.
COST: $1.1 million
LOCATION: **Thurston County**

TITLE: I-90 TRUCK/WIND WARNING SYSTEM NEAR COLUMBIA RIVER
OBJECTIVE: The Vantage Bridge, which carries I-90 across the Columbia River, is frequently subjected to very high cross winds. These winds can make it difficult for large trucks to safely traverse the span. The bridge has a history of semi-trailer, blow-over accidents. In addition, trucks approaching the bridge from the east must negotiate a sweeping turn onto the bridge at the end of a long downhill grade. This project will install a safety system comprising weigh-in-motion and radar detection along with a variable message sign to warn truckers that are traveling too fast to slow down. It will also install a real time high wind warning system.
COST: $250,000
LOCATION: GRANT COUNTY

TRANSPORTATION EMERGENCY OPERATIONS PROJECTS

TITLE: REMOTE TRAFFIC OPERATIONS CENTER FOR SECURITY AND EMERGENCY APPLICATIONS
OBJECTIVE: WSDOT's Puget Sound area traffic operations center (commonly called the TSMC) is a vital component of the region's plan to manage the ground transportation system during major emergencies. This project will develop a remote, virtual traffic operations center that would allow WSDOT to move the control of the existing TSMC to a remote location such as the Emergency Operations Center (EOC) at Camp Murray when needed.
COST: $500,000
LOCATION: **King County**

CONGESTION RELIEF PROJECTS

TITLE: VANCOUVER AREA SMART TREK OPERATIONS AND COMMUNCATIONS EXPANSION AND TRAVELER INFORMATION INTEGRATION

OBJECTIVE: The Clark County region currently has a small number of cameras and detectors on the freeway system. The project will install additional equipment on I-5, I-205 and SR-14. The additional equipment will have several benefits. These include improved freeway management with expanded incident detection and response capabilities, notification to the public of traffic conditions and alternate routes, and the deployment of a comprehensive congestion map of real time traffic information. The project will also include connecting Oregon DOT, C-TRAN and the City of Camas to the regional communications network and integrating the exchange of information between all the key transportation agencies in the area.

COST: $1.75 million
LOCATION: **Clark County**

TITLE: TRI-CITIES ADVANCED TRAFFIC MANAGEMENT SYSTEM

OBJECTIVE: This project will provide the operational and communication infrastructure that will interconnect the traffic signal systems of WSDOT and the cities within the Tri-Cities area (Richland, Pasco, and Kennewick). This will allow the multiple systems to work in concert providing operational efficiencies that will reduce traffic delay and motorist frustration.
COST: $1.0 million
LOCATION: **Benton and Franklin Counties**

TITLE: OLYMPIA ARTERIAL ADVANCED TRAFFIC MANAGEMENT SYSTEM

OBJECTIVE: This project will provide the operational and communication infrastructure that will interconnect the traffic signal systems of WSDOT and the City of Olympia. This will allow the two systems to work in concert providing operational efficiencies that will help reduce traffic delay and motorist frustration.
COST: $1.0 million
LOCATION: **Thurston County**

TITLE: SEATTLE INCIDENT AND OPERATIONS DEPLOYMENT

OBJECTIVE: Seattle is and will be experiencing several major road construction projects that significantly impact traffic for extensive periods. Incident response and clean up also frequently impedes traffic operations. The project would provide portable traffic operations ITS infrastructure that could be deployed on a temporary basis to improve traffic operations during construction, incidents and major events. This project will also expand the city's existing traffic camera system to principle city routes such as the West Seattle Freeway. This will provide more timely information on traffic conditions, better system wide traffic management coordination, and increased security monitoring of several critical transportation facilities within the city.
COST: $1.2 MILLION
LOCATION: **King County**

TITLE: SPOKANE TRAFFIC OPERATIONS FOR ARTERIALS

OBJECTIVE: The Spokane area has undertaken a comprehensive effort to provide a regional traffic operations system. The system will monitor the state highway system within the area and

provide operating agencies and the public with important information about traffic conditions and problems. This project will integrate Spokane area arterials into the regional operations system making it a truly comprehensive regional operational system.
COST: $1.2 million
LOCATION: **Spokane County**

TITLE: MAJOR EVENT PARKING ADVISORY SYSTEM
OBJECTIVE: Special event bound drivers approaching the three major event venues in downtown Seattle would benefit from improved guidance and information about available parking. The project would implement guidance signs with parking garage space availability information to inform drivers of their choices thereby reducing unnecessary traffic circulation. This project will also deploy a traffic information radio broadcast system for timely information on event parking, traffic congestion, construction and incident information. Overall, these systems would reduce unnecessary delay and related congestion, and reduce traffic conflicts.
COST: $1.1 million
LOCATION: **King County**

TRAVELER INFORMATION PROJECTS

TITLE: VARIABLE SPEED LIMIT SYSTEM ON STEVENS PASS, US-2
OBJECTIVE: In 1996 WSDOT installed a Variable Speed Limit system across Snoqualmie Pass on I-90 through the Cascade Mountains. This system adjusts the legal speed limit of the roadway based on prevailing weather conditions and congestions patterns. The system, which was installed to reduce winter accidents, has been proven to be very effective, reducing accidents and reducing weather related congestion. This project will install a functionally similar variable speed limit system on the high accident corridor on US-2 on Stevens Pass.
COST: $750,000
LOCATION: **Chelan County**

TITLE: US-395 COLUMBIA RIVER BRIDGE TRAFFIC OPERATIONS AND TRAVELER INFORMATION SYSTEM
OBJECTIVE: The Blue Bridge on US-395 across the Columbia River connects Pasco and Kennewick and is a critical transportation link for the Tri-Cities. It experiences heavy congestion and has a high accident rate. This project will install monitoring equipment, signs and communications on the structure to help alleviate these problems. The system will be tied into WSDOT's regional traffic operational center.
COST: $500,000
LOCATION: **Benton County**

TITLE: CENTRAL WASHINGTON TRAVELER INFORMATION VARIABLE MESSAGE SIGN (VMS) SYSTEMS
OBJECTIVE: Variable message signs installed along the highway deliver important accident, construction delay, and weather information to motorists. This project will allow WSDOT's regional operations center in Union Gap to communicate with motorists and truckers on several critical transportation links in Central Washington using variable message signs. Locations include I-90 near Moses Lake, US-97 near Oroville, and SR-243 near Beverly.
COST: $1.0 million

LOCATION: **Adams and Grant Counties**

TITLE: I-82 YAKIMA AREA TRAVELER INFORMATION SYSTEM
OBJECTIVE: This project will install variable message signs and highway advisory radio systems in the I-82 and US-12 interchange area to advise motorists of construction activities, congestion and accident information and hazardous road and weather conditions. The system will be connected to WSDOT's regional highway operations center in Union Gap.
COST: $500,000
LOCATION: **Yakima County**

TITLE: I-5 THROUGH NISQUALLY VALLEY - ICE WARNING SYSTEM.
OBJECTIVE: Interstate 5 through the Nisqually Valley has one of the highest frequencies of ice related accidents in the Tacoma/Olympia area. This project will install weather information stations, cameras, and changeable message signs that will be used to monitor pavement and traffic conditions and provide real-time information to motorists traveling through this area. This system will be integrated into the WSDOT Road and Weather Information System (RWIS) and the Olympic Region Traffic Management Center operations. This system will also be integrated with and enhance the existing highway advisory radio systems installed in this area.
COST: $500,000
LOCATION: **Thurston and Pierce Counties**.

TITLE: SR14 TRAVELER INFORMATION ENHANCEMENTS
OBJECTIVE: State Highway 14 east of Vancouver takes travelers on a breathtaking highway through the beautiful and historically rich Columbia River Gorge. The winding narrow road is heavily traveled by tourist and commercial vehicle traffic and is often subject to difficult weather conditions. This project will install variable message signs and highway advisory radios within the corridor to advise motorists of traffic and weather conditions on this highway. The system will be tied into the regional highway operations center in Vancouver that will provide travel condition information to the local media and on the Internet.
COST: $250,000
LOCATION: **Skamania County**

APPENDIX C: LONG HAUL TELECOMMUNICATIONS PROVIDERS IN WASHINGTON

APPENDIX D: 360NETWORKS I-5 FIBER ROUTE

APPENDIX E: SAMPLE 360NETWORK AGREEMENT LETTER

360networks
2401 4th Avenue
Seattle, WA 98121

(t) 206.239.4360
(f) 425.988.0983
www.360.net

December 9th, 2002

Adrian Pearmine, P.E.
Associate
IBI Group
1022 SW Salmon Street
Suite 460
Portland OR 97205

Re: Washington State Dark Fiber Quote

Dear Adrian,

As you requested, I have revised the quote that I sent to you on December the 5th.

The new proposal is as follows:

1) Vancouver, WA to Seattle
Term: 20 Year IRU
Fiber IRU Non-recurring Charge: $277,100 (2 fibers)
Route Maintenance Yearly Recurring Charge: $57,050 ($350 per route mile)

2) Seattle to Vancouver, BC
Term: 20 Year IRU
Fiber IRU Non-recurring Charge: $738,000 (2 fibers)
Route Maintenance Yearly Recurring Charge: $71,750 ($350 per route mile)

Other Services:
Splicing Non-recurring Charge: $5,000 per splice
Collocation: $750 per rack (Monthly Recurring Charge), $1,000 per Rack Installation Fee
Power: $15 per amp (Monthly Recurring Charge)

Please note that,

i. The attached quote, valid for 30 days, is budgetary and as such is subject to the execution of a definitive agreement between our two companies.
ii. All services pertaining to this quote are available in inventory today. However, inventory is depleted on a first come, first served basis based on contract execution.
iii. The information contained in this quote is proprietary and confidential.

Please review the material contained in this quote, and feel free to call me with any questions or comments you may have regarding this offer.

Sincerely,

Jeff Lawton
Account Executive
360networks, Inc.
(w) 206.239.4077

APPENDIX F: NOANET STATEWIDE NETWORK IN WASHINGTON STATE

APPENDIX G: MCI CIRCUIT PRICING ESTIME

Site 1		Site 2				
Name	AC & Prefix	Name	AC & Prefix	Circuit Size	Initial Install Cost	Monthly Lease Price
WSDOT HQ	(360) 705	Vancouver Reg HQ	(360) 905	T1	$800	$790
	(360) 705		(360) 905	DS-3	$1,200	$8,383
WSDOT HQ	(360) 705	Oly Reg HQ	(360) 357	T1	$800	$644
	(360) 705		(360) 357	DS-3	$1,200	$8,157
WSDOT HQ	(360) 705	Wenatchee Reg HQ	(509) 667	T1	$800	$1,070
	(360) 705		(509) 667	DS-3	$1,200	$10,657
WSDOT HQ	(360) 705	Yakima Reg HQ	(509) 577	T1	$800	$813
	(360) 705		(509) 577	DS-3	$1,200	$8,265
WSDOT HQ	(360) 705	Dayton Reg HQ	(206) 440	T3	$1,200	$8,468
	(360) 705		(206) 440	OC-3	$20,000	$26,507
WSDOT HQ	(360) 705	Spokane Reg HQ	(509) 324	T1	$800	$644
	(360) 705		(509) 324	DS-3	$1,200	$8,156
WSDOT HQ	(360) 705	WSF "2911 Building"	(206) 515	DS-3	$1,200	$7,714
	(360) 705		(206) 515	OC-3	$20,000	$17,782
Dayton Reg HQ	(206) 440	Bellingham TMC	(360) 676	T1	$800	$644
	(206) 440		(360) 676	2- T1s	$1,600	$1,288
Wenatchee Reg HQ	(509) 667	Yakima Reg HQ	(509) 577	T1	$800	$1,070
	(509) 667		(509) 577	DS-3	$1,200	$10,577